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THE PETROLEUM ENGINEER PUBLISHING COMPANY
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You needn't wait for Thanksgiving

Everyone from John Q. Public to Joe Citizen realizes, somehow, that the transport truck lines are doing a perfectly thundering war job.

But if most people are a mite vague about it, that's no wonder. Even the experts are amazed at the whole story. For, by their service to communities large and small, the auto fleets are keeping America in gear — and high gear at that.

You know the truck operators are in there pitching when you realize they're up against the same war-time difficulties that beset any individual motorist—only multiplied to giant proportions.

Short of manpower and maintenance help—battling to solve scarcity problems on tires, gasoline and equipment—they still keep pushing those big multi-wheeled babies over the highways.

It's only a fly-weight exaggeration to suggest that, without transport trucking service, we'd be fighting a war with muzzle-loaders and ox-teams. Life at home, too, would be pretty rugged.

One reason it's hard to appreciate the contribution of the trucks is that transport trucking is about the youngest of the industries. It's like the Air Force. A few years ago it almost didn't exist. But now look!

Another reason is that few people get out on the highways these days. You don't see the transport trucks a-rolling. But you needn't wait for Thanksgiving to be thankful that—like the stars on a cloudy night — although you don't see them, they're on the job.

STANDARD OF CALIFORNIA

E flag, with 3 stars, awarded to our Richmond Refinery

The Course of Oil

K. C. SCLATER

PRESENT AGREEMENT UNACCEPTABLE

The oil industry has been asked by Mr. Ickes to submit specific constructive suggestions for changes in the language of the Anglo-American Petroleum Agreement. In its present form, the Agreement is not acceptable to the oil industry. Why? J. Howard Pew in a statement before the P.I.W.C. on October 23, 1944, gives several very important reasons why. He states that the Agreement as now written "is a deliberate attempt to place the American petroleum industry under the bureaucratic control of the Federal Government. It is a blank check which would give to the Federal Government unlimited and unspecified powers of the greatest scope over every activity of our industry. The effectuation of its objectives can be achieved only through embroiling our domestic petroleum industry in a vicious cartel system. This would halt the progress of our industry and be detrimental to the welfare of every one in our country. * * *

"This Agreement sets forth objectives which can be achieved only through production control, or control of marketing, or control of prices, or all of these. * * *.

"What is that, but a cartel? Such arrangements in international trade are exactly what we at home call monopolistic practices or combinations in restraint of trade. For more than fifty years, such practices have been outlawed by our anti-trust legislation. The evil and reprehensible nature of such practices is beyond dispute. The fruits of such practices have been to freeze initiative; to close the door of opportunity for new individual entrepreneurs; to destroy small business units; to encourage inefficiency; to raise prices, and to lower the standard of living. * * *

"For more than thirty years the American petroleum industry has grown great by shunning just such practices. Instead we have engaged in spirited competition, with the result that our industry has expanded from year to year, giving to consumers better and better products, at lower and lower prices, and at the same time we have been able to pay increasingly higher wages to those employed in the industry. In the domestic field we have chosen the road of competitive enterprise and freedom of opportunity for all, because we have learned by experience that this road leads to success and to the highest degree of public service.

"Yet in this Agreement it is suggested that in the field of foreign operations we should embrace those very monopoly and cartel undertakings which are so obnoxious to us here at home.

"Make no mistake about it! International trade and domestic trade are not two different things. They cannot be isolated in compartments one from the other. They are parts of the same thing. This country cannot be cartelized in its foreign trade and free in its domestic enterprise, any more than a Nation can survive 'half free and half slave.' This is particularly true of the petroleum industry. Once we start to regiment through allocations, price fixing and production controls, our activities in the foreign field, we of necessity will have forced upon us by the Government, restrictive measures upon operations that fall wholly within the domestic field.

"Efforts have been made in some quarters to distinguish between so-called 'private cartels' and cartels under government control. The argument seems to be that the public welfare is protected when the government fosters and directs the cartel. I agree there is a great distinction. It is that cartels under the aegis of government are *far more reprehensible* and *detrimental* to the public welfare than cartels entered into by individual companies. * * *

"To make a petroleum cartel effective in this country, it must necessarily be implemented by the lash of governmental authority so that every unit in the industry, every independent producer, every small refiner, as well as large companies, must conform to the cartel restrictions. This is the type of cartel inherent in the Anglo-American agreement. Such a cartel is far more reprehensible than the recent NRA. Such a cartel would mean the end of thousands of small, independent producers and refiners. These are the very men whose initiative and ingenuity have made our industry great. There is no place under a cartel supported by the power of government for either independence or independent operators. * * *

"If our country embarks upon this step it will be only a short time before our industry passes into government-ownership, with all the paralyzing inefficiencies that attend efforts of government to operate industry. * * *

"The Oil Cartel Agreement is the first of a long series of similar cartels which the economic planners are preparing to ram down the throats of the American people. Because oil is the first of these agreements, and because we have had the opportunity of familiarizing ourselves with all of its implications, it becomes our solemn duty, as American citizens, to state our objections clearly and fully so that the Senate of the United States, as well as the American people, shall have a full understanding as to what is comprehended. * * *"

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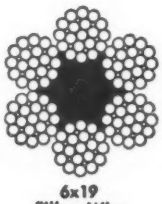
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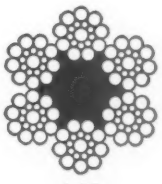
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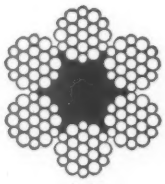
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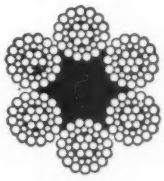
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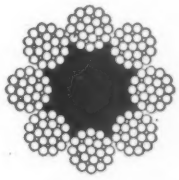
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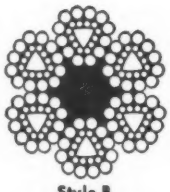
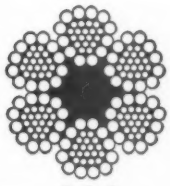
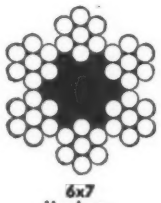

Style B Flattened Strand

WIRE ROPE for your HEAVY DUTY JOBS


Style G Flattened Strand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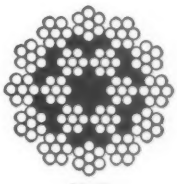
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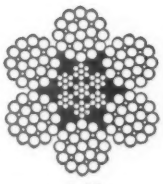
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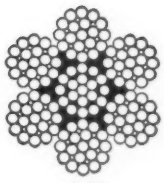
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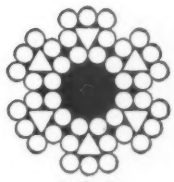
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National Petroleum Situation

CRUDE STOCKS UP 9,000,000 BARRELS. Stocks of crude oil in the United States at the close of October were approximately 9,000,000 bbl. greater than at the close of September. On a current demand basis this gain was equivalent to three additional days of supply. Compared with a year ago, however, the stored supply of crude oil is now sufficient to last 48 days, whereas a year ago the supply amounted to 56 days.

NO LET-UP IN CRUDE DEMAND. Demand for crude oil in October aggregated over 149,000,000 bbl., only slightly below the September figure. There is little reason to expect any material decline in demand for crude oil in the near future. The daily average demand for domestic crude in the fourth quarter of this year has been estimated by the U. S. Bureau of Mines at 4,760,000 bbl., compared with 4,720,000 bbl. in the third quarter.

CRUDE PRICE ADJUSTMENTS. Upward OPA revisions in crude prices, effective November 9, will not noticeably affect the general average price structure. Joes Lake and Silsbee, Texas, crudes were granted increases averaging 11 cents per bbl.; Abell and Barnhart (Ordovician), Texas, an increase of 13 cents; Lisbon, Louisiana, field, 20 cents; and 21 Louisiana, 2 Kansas, and 5 Oklahoma fields were placed under a uniform $1.30 per bbl. for 40 gravity oil.

MORE DRILLING RIGS NEEDED. Latest available information is that about 1750 rotary rigs are now in operation. New drilling operations, including active drilling wells, shut-down rigs, and new locations staked, shows that about 4200 new operations were listed at the close of October. While this is 53 per cent above a year ago, it is believed that the drilling program established for next year—27,000 wells—will necessarily call for a substantial increase in rigs as well as the availability of more materials.

WILDCATS CONTINUE TO LAG. Wildcat operations for this year have noticeably fallen behind schedule. Wildcats drilled over the past 10 months total 3180, which is considerably below the cumulative total necessary to meet this year's wildcat program of 5000 wells. Indications point to not more than 3880 to 3900 wildcat wells for all of 1944, which will be about 1100 wells short of the goal set early in the year by PAW.

FUEL OIL PICTURE IMPROVED. Stocks of fuel oil continue to increase. Combined stocks of light and heavy fuels at the close of October showed a further gain of 2,800,000 bbl. more than September and are nearly 6,000,000 bbl. above a year ago. It should be noted, however, that on the basis of current requirements today's stocks of all fuels are at relatively the same level as a year ago. In other words, the industry now has 56 days supply of fuel oil, which is relatively the same level as a year ago. The cumulative demand for fuel oil in 1944 is shown to be about 9 per cent above the same period of last year.

Comparative Statistics, October, 1944

*All figures are computed on a Bureau of Mines basis.**

	October 1944(p)	Sept. 1944(p)	October 1943	This year to date	Last year to date	Per cent change
Wells drilling	4,200	4,215	2,751	4,200	2,751	+53
Total wells drilled	2,102	2,060	1,635	18,164	14,444	+26
Development wells	1,757	1,728(r)	1,340	14,984	11,698	+28
Oil	1,205	1,191(r)	883	10,376	7,518	+38
Gas	197	207(r)	165	1,760	1,436	+23
Dry	355	330(r)	292	2,848	2,744	+ 4
Per cent dry	20.2	19.1	21.8	19.0	23.5	— 4.5
Wildcat wells	345	332(r)	295	3,180	2,746	+16
Oil	47	46(r)	39	393	359	+ 9
Gas	13	11(r)	10	102	54	+89
Dry	285	275(r)	246	2,685	2,333	+15
Per cent dry	82.6	82.8	83.4	84.4	85.0	— 0.6
Crude production	147,160	142,160	136,503	1,389,460	1,389,378	+13
Daily average	4,747	4,739	4,403	4,556	4,060	
Crude stocks	229,340	226,412	248,167	229,340	248,167	— 8
Days supply	48	45	56	48	56	
Crude demand†	149,136	149,553	136,250	1,441,277	1,205,547	+20
Daily average	4,811	4,985	4,395	4,725	3,966	
Natural gasoline production	¶8,990	¶8,590	¶8,034	84,067	74,694	+13
Daily average	290	286	259	276	246	
Motor fuel production	65,640	61,920	56,816	611,214	497,644	+23
Daily average	2,117	2,064	1,833	2,004	1,637	
Gasoline yield, per cent	39.6	39.0	38.6	39.0	36.9	+ 2.1
Motor fuel stocks	69,450	69,500	63,565	69,450	63,565	+ 9
Days supply	33	33	34	33	34	
Motor fuel demand	65,690	63,795	57,160	611,269	509,483	+20
Daily average	2,119	2,127	1,844	2,004	1,676	
Fuel oil stocks	105,750	102,980	99,809	105,750	99,809	+ 6
Days supply	56	59	56	56	56	
Fuel oil demand	58,275	52,177	55,677	590,770	543,643	+ 9
Daily average	1,880	1,739	1,796	1,937	1,788	
Refinery still runs	142,165	139,750	129,036	1,378,256	1,171,209	+18
Daily average	4,586	4,658	4,162	4,519	3,853	
All refined stocks	260,500	253,470	234,065	260,500	234,065	+11
Days supply	53	54	53	53	53	

*Unless otherwise stated all figures represent thousands of barrels. (p)—Preliminary.
¶Includes benzol. †Domestic and foreign. (r)—Revised estimate. §No change since prices frozen. Prices do not include sibsidies.

Economic Position of Petroleum Industry

First ten months, 1944.

	Normal	Actual	Per cent of normal
Drilling (wells completed)	19,933	18,164	91
Production (daily average)	4,741	4,556	96
Refining (daily still runs)	4,629	4,519	98
Stocks (crude and refined)	580,196	489,840	84
Price of crude oil, per bbl. (a)	$1.95	$1.22	63

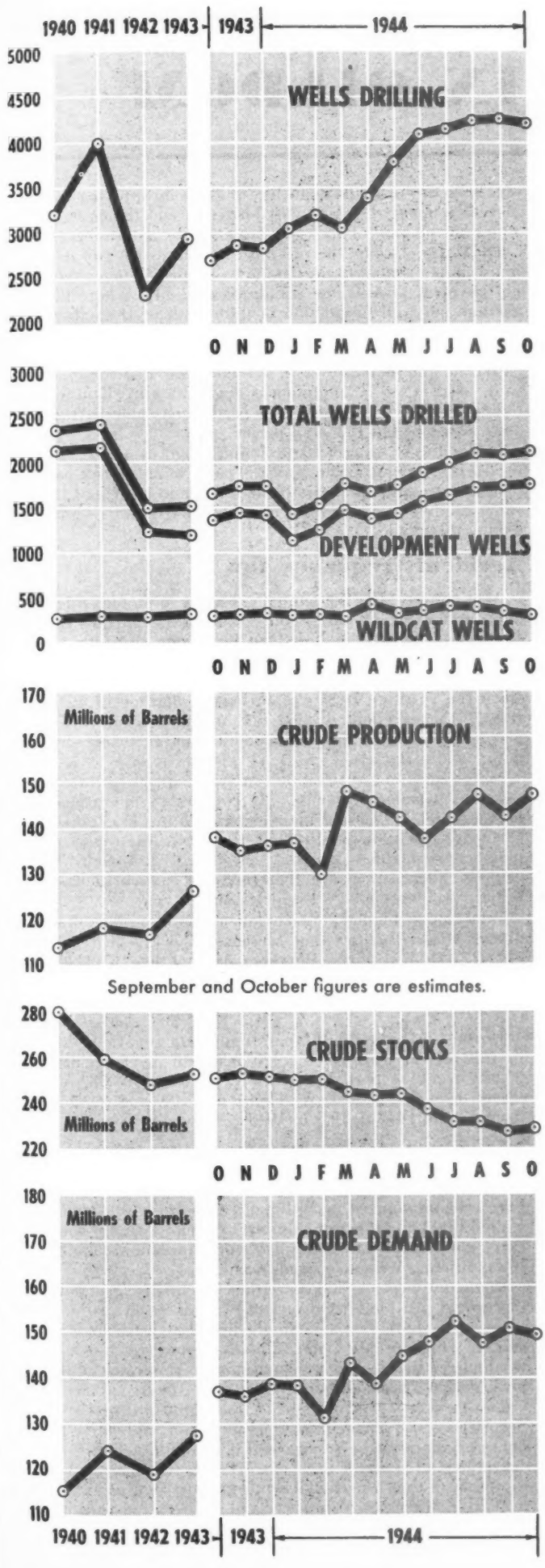
(a) Exclusive of subsidies.

Crude Prices by States for October, 1944§

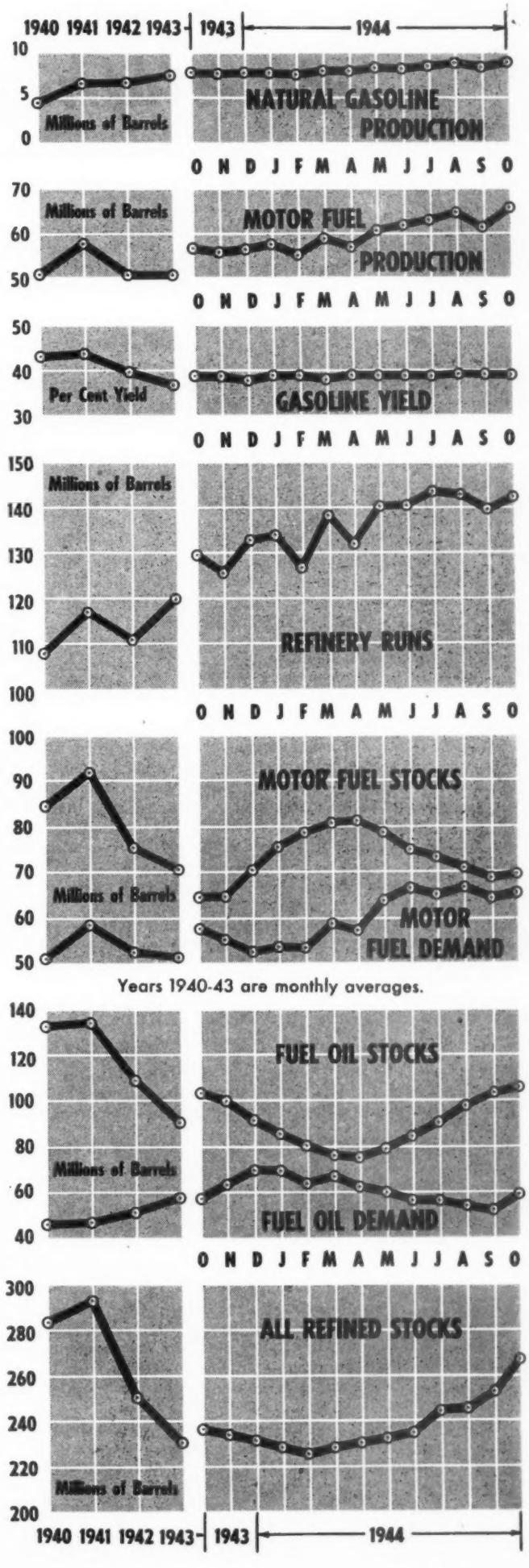
U. S. average	$1.22	Louisiana	$1.20	**Basic crude prices**	
Texas	1.23	Arkansas	1.25	Oklahoma-Kansas (36 gr.)	$1.17
California	1.07	New Mexico	1.04	Texas Gulf Coast (36 gr.)	1.40
Oklahoma	1.17	Mississippi	1.10	East Texas	1.25
Kansas	1.17	Illinois	1.37	West Texas (36 gr.)	1.04
		Other States	1.89	Calif., Signal Hill (26 gr.)	1.11
				Pennsylvania Bradford	3.00

Drilling and Production Statistics by States

	October 1944(p)	Sept. 1944(p)	October 1943	This year to date	Last year to date	Per cent change
Total wells drilled	2,102	2,060	1,635	18,164	14,444	+32
Texas	525	516	428	4,646	3,509	+32
California	188	167	126	1,640	1,124	+46
Oklahoma	163	200	62	1,414	970	+46
Kansas	175	152	139	1,522	1,379	+10
Louisiana	65	77	56	633	561	+13
Arkansas	17	11	32	235	215	+ 9
New Mexico	47	27	27	337	193	+75
Mississippi	9	17	14	107	80	+34
Illinois	194	175	199	1,498	1,480	+ 1
Other states	719	718	552	6,132	4,933	+24
Wildcats drilled	345	332(r)	295	3,180	2,746	+16
Texas	109	120	90	1,129	909	+24
California	17	7	14	167	166	+ 1
Oklahoma	30	45	26	304	255	+19
Kansas	58	48(r)	28	441	376	+17
Louisiana	13	10	9	108	101	+ 7
Arkansas	5	1	4	52	57	— 9
New Mexico	4	5	2	54	42	+29
Mississippi	2	8	11	66	36	+83
Illinois	43	20	39	305	363	—16
Other States	64	68(r)	72	554	441	+26
Daily crude production	4,747	4,739	4,403	4,556	4,060	+12
Texas	2,154	2,174	1,910	2,027	1,567	+29
California	888	877	786	846	776	+ 9
Oklahoma	342	335	334	334	338	— 1
Kansas	275	268	275	271	295	— 8
Louisiana	353	355	353	353	337	+ 5
Arkansas	83	80	78	81	75	+ 8
New Mexico	103	105	111	109	104	+ 5
Mississippi	48	47	46	44	53	—17
Illinois	200	202	221	211	226	— 7
Other States	301	295	289	280	289	— 3



September and October figures are estimates.



Years 1940-43 are monthly averages.

Highlights IN OILDOM

PAW acts to avert butane shortage

The natural gas and natural gasoline division of the Petroleum Administration for War has issued an order in collaboration with the American Association of Oilwell Drilling Contractors in an effort to avoid a shortage of butane fuel for drilling rigs this winter. An attempt is being made to have owners convert from 250 to 300 rigs to the use of natural gas in areas where gas is available. Some operators are converting to propane, but difficulty is also being experienced in obtaining propane.

James E. Pew, director of the natural gas and natural gasoline division of PAW, is reported as saying that the butane shortage is so acute that drilling rigs would be shut down if necessary to conserve this fuel.

Virtually all available supplies of butane are needed for the manufacture of aviation gasoline. In addition, in southern states where natural gas is not available considerable butane is used for domestic heating and PAW is seeking to assure sufficient supplies for this purpose.

It is estimated that 750 rigs are using butane for fuel at present with most of them in West Texas Permian Basin, New Mexico, Arkansas, and Mississippi. West Texas, New Mexico, and Arkansas account for a large number because of the sulphur content of the natural gas available for drilling use, which cannot be used without cleaning.

Research program for eastern fields

The Pennsylvania Grade Crude Oil Association has subscribed $150,000 and a like amount is being sought by subscription from the petroleum industry, for purposes of instituting a production research program planned primarily for recovery of vast amounts of oil existing in the eastern area that would not be obtainable by known methods. The program calls for expenditure of $100,000 a year for three years beginning with 1945.

Association officials say that recognized authorities have repeatedly estimated that after known methods have been exhausted, 5,000,000,000 bbl. of oil will remain in place in Pennsylvania fields. If only 20 per cent of this can be recovered as a result of research studies, the life of the Pennsylvania grade oil fields will be doubled.

Stripper subsidy deadline January 1, 1944

The office of Price Administration has emphasized that no pool discovered after January 1, 1944, can qualify for price increases under the stripper well subsidy plan unless the increase is specifically allowed in an amendment or order issued by OPA.

This announcement was made in connection with the listing of all crude oil pools qualifying for inclusion in the subsidy plan to last October 1. The comprehensive summary includes the pools originally announced, those included in 20 orders subsequently issued and with a number of modifications and corrections.

OPA stressed that pools discovered after January 1, 1944, must come under the plan by special order because some of the price increases are allowed in blanket form covering an entire state, or county, or an otherwise broadly described area. New pools, which do not qualify under the premium payment standard that come into production in these sections with blanket coverage, might adopt the increased ceiling price unless this restriction was levied.

OPA also inserted into the summary a provision authorizing the adjustment by order of prices in pools producing 9 bbl. or more per well daily where: (1) Because of high cost factors the maximum price for crude oil is below the average cost of production, and (2) the cost of production is not out of proportion to the output obtainable.

A separate announcement already has been made by OPA detailing the procedures to be followed in applying for price increases under this high cost provision and the principles on which the amount of such increases will be determined.

OPA also clarified the two basic standards used in determining what pools qualify for the increased prices under the premium payment plan. These standards are: (1) Where the daily average per well production in the month of December, 1943, was less than 9 bbl., and (2) where the daily average per well production for the 12-month period preceding the date of application for the increase was less than 9 bbl. and the number of wells used in the computation is determined by dividing by 12 the sum of the number of wells producing crude petroleum in each month of the 12-month period.

Under the stripper well premium payment plant, OPA has increased crude oil prices from 20 cents to 35 cents a barrel on pools meeting the qualifying standards, and increased Pennsylvania grade crude oil prices 75 cents a barrel on all pools producing this grade.

Accident frequency low

According to the 12th annual summary of motor-vehicle accidents compiled and just published by the department of accident prevention of the American Petroleum Institute, accident frequency in the operation and maintenance of automotive equipment by oil companies during the year 1943 was the lowest since the Institute began reporting the figures in 1932. This reflects the excellent driving and maintenance record of the petroleum industry despite acute wartime shortages of manpower and materials.

In response to the Institute's annual request for information concerning traffic accidents, 151 companies, operating 48,996 motor vehicles, reported their experience to the department of accident prevention for 1943. Thirty-four of the reporting companies were unable to give data on the mileage traveled by their vehicles; their experience, therefore, was summarized as motor-vehicle accidents per 100 vehicles only.

Information for 117 oil companies, operating 45,032 vehicles during 1943, discloses that these vehicles traveled a total of 612,927,541 miles during the year; and that these 45,032 vehicles had 1.14 accidents in each 100,000 miles of travel—that is to say, each vehicle operated had one accident in 87,386 miles of travel.

During 1943 the 18,817 passenger cars reported separately in the report, traveled 151,920 miles to each accident; the 25,985 trucks reported separately, averaged 68,032 miles of travel to each accident. Accidents per 100 vehicles decreased from 17.3 in 1942 to 15.5 in 1943.

Another long gas line proposed

Plans for construction of a $70,000,000 natural gas pipe line have been announced by William G. Woolfolk, president of the United Light and Power Company, Chicago. The pipe line would carry gas from the Hugoton fields of Kansas and Oklahoma to Iowa, Illinois, Wisconsin, and Michigan.

Company engineers have worked out plans, Woolfolk said, that would provide for delivery of twice as much gas in one day as is now possible from a single line. Extensive underground storage fields in Michigan, already owned by the company, would be utilized. The unusual storage program would meet peak period of consumption.

The project is said to depend upon approval of the federal Securities and Exchange Commission for an application to liquidate and dissolve the American Light and Traction Company, subsidiary of United Light and Power Company. Approval would mean that American Light's gas distributing subsidiaries in Detroit, Michigan, Milwaukee and Madison, Wisconsin, would become completely independent and would own and operate the pipe line.

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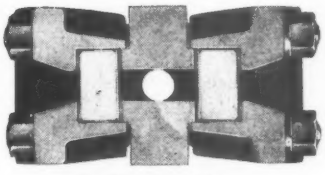

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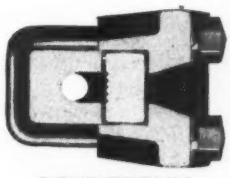

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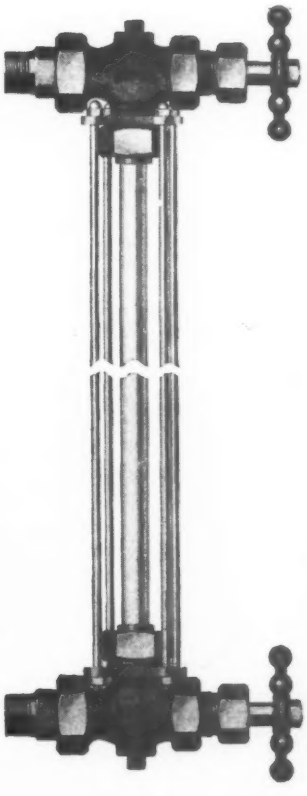

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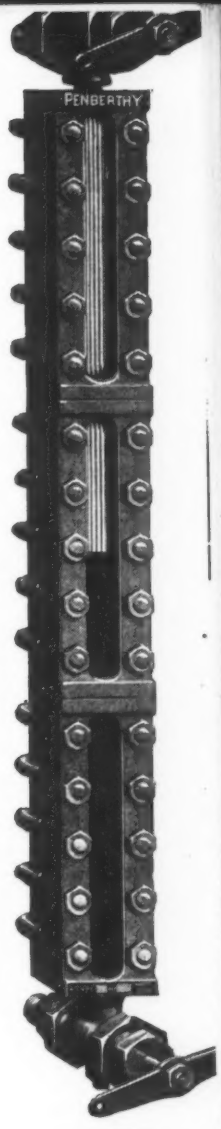

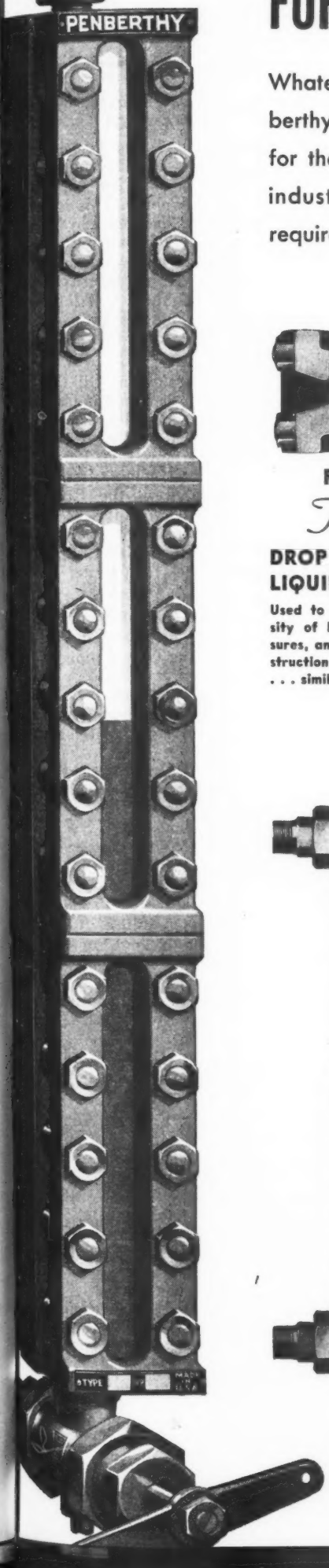

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MAJOR *Oil Field* ACTIVITIES

▸ **NEBRASKA.** L. M. Bates, No. 1 Fritz, SE SE SE 34-3s-15e, a wildcat test a mile and a half north of Verdon, Richardson County, southeast Nebraska, opens the first new pool in the Cornhusker State in many months. Associated with Bates are Edwin S. Towle and John Peters of Falls City. The B and T Drilling Company of Falls City tested with rotary tools and reported oil showing. The report was substantiated by Cities Service Oil Company. Potential of the new producer had not been determined.

▸ **NEW MEXICO.** The first Permian production for New Mexico was discovered by Gulf Oil Corporation with the opening of No. 1 Drinkard, 30-22s-38e Lea County. The discovery for Clear Fork production tested at 6375-6430 ft.

The second recent important strike for New Mexico is Gulf Oil Corporation's No. 1 Vivian, section 30-22s-28e, 2 miles east of production in the shallow upper Permian Penrose pool, Lea County. The well flowed at the rate of 25 bbl. per hr. of 37.4 gravity sweet oil from 6365-6450 ft. The pool opener is 15 mi. southwest of the Fullerton pool.

▸ **ARKANSAS.** Carter Oil Company's discovery well a mile west of Mt. Holly, Union County, has been connected to pipe lines by the Lion Oil Refining Company, which is taking both the gas and condensate. The well is the No. 1 G. F. Wilson in C SW NW of 33-16s-18w. It was drilled to 7091 ft. and tested for 52 bbl. of oil from the Smackover lime at 6895-6998 ft.

▸ **ILLINOIS.** Two new pools for Franklin County, 25 mi. apart, were brought in recently within a few hours of each other. The first, drilled by Smokey Oil Company, was in Union Township, section 4, 2½ mi. northwest of Ewing. Oil was found at a depth of 2865 ft. The second well was struck at 3152 ft., by Deep Rock Oil Corporation and Oil Exchange, Inc., drilling jointly. It is in section 15 of Cave Township, one mile east of Thompsonville. The wells were estimated to be worth at least 700 bbl. of oil each daily.

▸ **KENTUCKY.** Ross Bartmes, T. M. Pruitt, Sam Arscht and Charles Pollock have given Webster County a Tar Springs sand producer at 1908-20 ft. The well, 2 mi. south of Poole, is estimated to produce from 100 to 200 bbl. of oil per day.

▸ **KANSAS.** The Stanolind Oil and Gas Company has opened what appears to be a major gas pool at its No. 1 Collmac, in the C of 32-30-39w, 6 mi. west of the Hugoton gas field in Stanton County. The hole was carried to 2725 ft. and plugged back for testing. It is making an estimated 60,500,000 cu. ft. of gas daily.

▸ **TEXAS.** The first Viola lime production in North Texas has been assured with the opening of Continental Oil Company's No. 1 McNutt, Burnett-McNutt survey, in Montague County. A substantial increase in the showing of oil has been reported by the company in the upper Ordovician wildcat. It flowed 146 bbl. of oil and 11 bbl. of water in a 24-hr. test with casing pressure of 500 lb. from 6715-30 ft.

Fain and McGaha of Wichita Falls have opened a Canyon lime oil pool in northwestern Wilbarger County, 10 mi. northwest of Vernon and 4½ mi. northwest of the Fargo pool. The discovery flowed 252 bbl. of 41-gravity oil in 24 hr. from 4750-4810 ft. with gas-ratio of 420 cu. ft. of gas to 1 bbl. of oil.

D. S. Johnson of Wichita Falls has opened two new shallow oil pools for Cooke County. His No. 1 Gatewood, M. E. P. and P. Survey, topped a saturated oil sand at 1568 ft. and cored from 1571-81 ft. with recovery of 10 ft. of sand showing oil. The well is estimated as a 200-bbl. daily producer. The second strike is No. 1 Trukenbach, block 766, B. B. B. and C. survey which drilled to 1572 ft. cemented casing at 1561 ft., drilled plug, swabbed, and tested. The wildcat indicates commercial production.

Rusk County has a new gas-condensate field 9 mi. southeast of Henderson in the Brachfield community where H. C. Owen No. 1 Rousseau, Wilkerson survey, made an estimated 5,000,000 cu. ft. of gas and 100 bbl. of condensate daily. Production is from the Travis Peak basal Trinity. Hole is bottomed at 7510 ft. The Pettit lime is also reported to have been porosity and an odor of wet gas.

Tide Water Associated Oil Company has opened a new gas-condensate pool in Colorado County with its No. 1 D. L. Underwood. The producer is located 3 miles northwest of Sheridan. It flowed at the rate of 70 bbl. of 57 gravity condensate daily with 672,000 cu. ft. of gas on drillstem test from the Wilcox sand from 9500-02 ft.

Humble Oil and Refining Company has opened a new Permian lime pool of undetermined proportions in southern Gaines County, West Texas with its No. 1 Doss, sec. 9, block A-24, public schools land survey. The discovery was reported to have flowed at the rate of 10 bbl. of oil and hour after being treated with acid. The wildcat was carried to 9049 ft. but, after none of the lower sections showed for commercial production, was plugged back to total depth 7250 ft.

Amerada Petroleum Corporation has given Wharton County another Frio sand oil producing pool with No. 1 Dabova, about 2 miles southwest of El Campo. The well flowed 80 bbl. of 45.7 gravity crude oil on a 24-hr. test through ⅛-in. choke. It produced through casing perforations from 7025-27 ft. in top of the sand section of the lower Frio.

▸ **CALIFORNIA.** Tide Water Associated Oil Company has announced completion of Gosford discovery well No. 62, section 22-30-26, Kern County. This is the third new field to be discovered by Tide Water Associated in the vicinity, the company having previously discovered the East and West Strand fields. On a 24-hr. production test, the new well flowed at the rate of 1200 bbl. gross, 935 bbl. net 28.2 gravity oil, from a total depth of 7942 ft.

▸ **OKLAHOMA.** Continental Oil Company has opened another pool in Carter County with its No. 1 Fowler. The new producer, NW SE SW 31-2s-2w, is reported to be flowing more than 120 bbl. of oil per hour. The oil, coming from the Chimley Hill member of the Hunton lime, is of high gravity and is accompanied by an estimated 3,000,000 ft. of gas. Drilled originally to 5594 ft., the well was plugged back to 5044 ft.

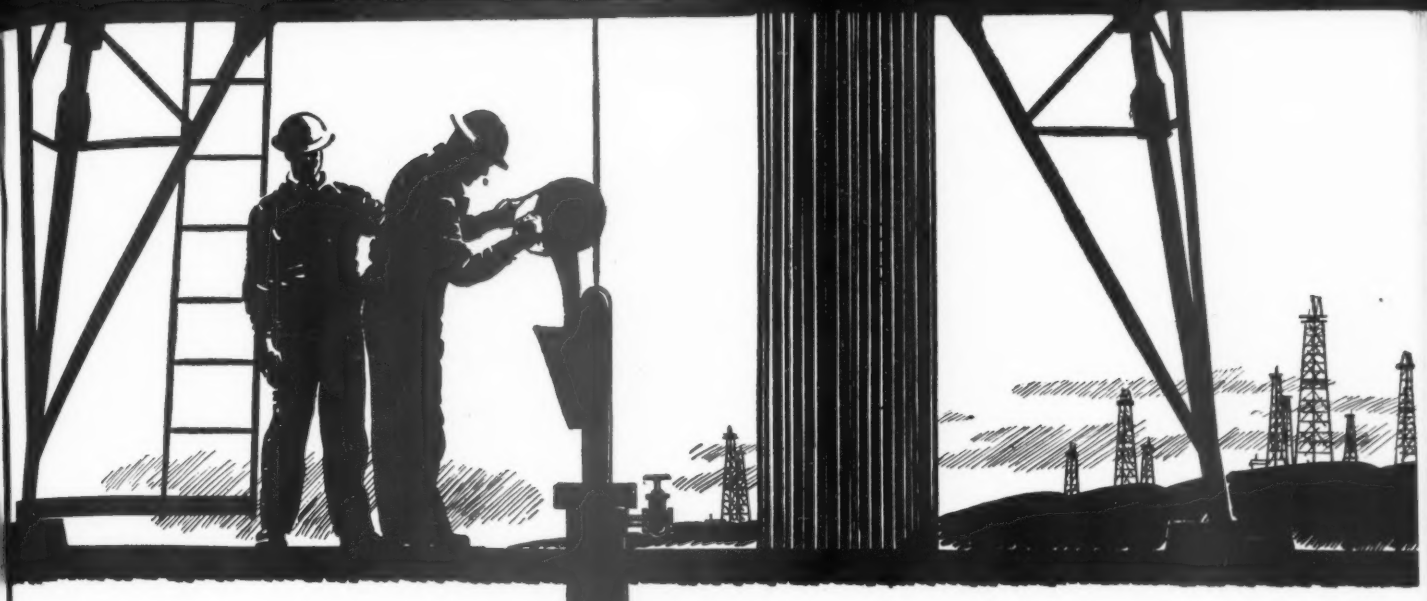
▸ **LOUISIANA.** Continental Oil Company has opened a new field in the Bayou Serpent area of Jefferson Davis Parish. Its No. 1 King Corporation, 30-7s-6w, was perforated at 7135-45 ft. and washed into production of 180 bbl. of oil a day. Gravity is 35.7 degrees, gas-oil ratio 672 to 1. Total depth of the well is 9302 ft.

The Barnsdall Oil Company and Sohio Petroleum Company have opened a new pool for Louisiana with the discovery of No. 1 J. T. Hanks, in C SW NE of 7-20n-12w, near Crystal, northeast of Benton, in Bossier parish. The well was drilled to 8762 ft. and backed up to 8390 ft. It is flowing an estimated 15,000,000 cu. ft. of gas daily from 8310-90 ft.

A new gas-condensate pool for southern Louisiana has been opened by Phillips Petroleum Company with No. 1 Onez in Acadia Parish. Production through perforations from 7738-41 ft. was ungauged.

▸ **WYOMING.** Sinclair Wyoming Oil Company No. 1 Unit, NW SW NW of 18-28n-92w, in the Crooks Gap area southwest of Casper, Fremont County, indicates a new pool for Wyoming. On a drillstem test in the Dakota formation, 1800 ft. of oil and some water was recovered. The company has set 5313 ft. of 7-in. casing, with total depth at 5316 ft. Nearest production to the discovery well is the Lost Soldier and Wertz fields about 20 mi. to the southwest.

Sinclair Wyoming has opened its second discovery well in Fremont County, with the completion of No. 1 Unit, in SW NW NW of 14-32n-95w, on Sand Draw, about 28 mi. from the Crooks Gap discovery. The Embar horizon was picked up from 6896-6963 ft. and showed 350 ft. of oil-cut mud and about 15,000,000 ft. of gas.



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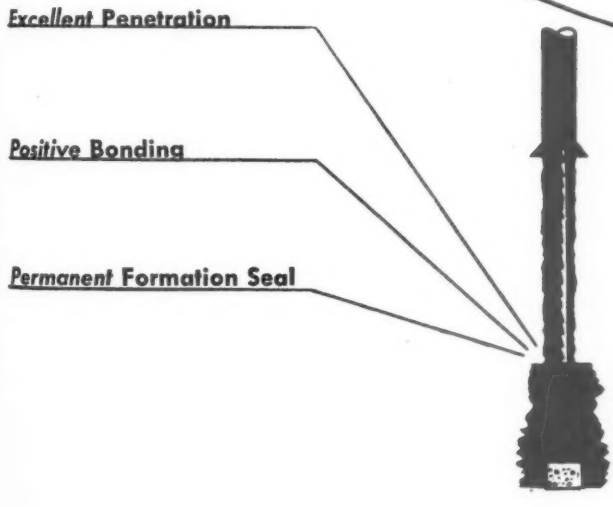

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MAJOR *Pipe Line* ACTIVITIES

▸ **FOUR TO GO.** Four major pipe line projects in the PAW program are still under construction according to late reports from administration headquarters. Those scheduled for completion this month are: Ohio Oil Company's 115-mi. 8-in. products line from Robinson, Illinois, to Indianapolis, Indiana, with total cost estimated at $1,547,150; Colonial Beacon Oil Company's 35-mi. 4 in. and 6-in. products pipe line from Everett to Methuen, Massachusetts; Utah Oil Refining Company's 112-mi. 6-in. crude line from Iles Dome, Colorado, to Wamsutter, Wyoming. The fourth remaining line in the project, that from Elk Hills Naval Reserve to refineries at Los Angeles, will be completed in December.

▸ **BIGGEST TANKER FLEET.** Tankers now owned and controlled by American operators, together with others to be constructed within the next few months, will "total a greater carrying capacity than the entire world fleet in 1940," according to a recent announcement by James P. Patterson, marine manager of the Pan-American Petroleum and Transport Company.

▸ **WEST EDMOND GETS LINE.** WPB has announced approval of equipment for construction of additional pipe line outlet for the growing West Edmond, Oklahoma, field, to cost approximately $300,000. The line will be a joint project of Standish Pipe Line Company and Sohio Petroleum Company. The 8-in. line will be 18 miles long and will extend from the field to a main line of the Standish Company east of Oklahoma City. The field, expected to have a daily production of 60,000 bbl. of oil by the end of the year, is now served by only one line.

Gas line in operation

Tennessee Gas and Transmission Company put its 1265-mi. pipe line from Texas to eastern points into operation October 31. Work was begun January 10, 1944. The line, 24 in. in diameter and costing around $54,000,000, is said to be the longest in the world. As each section was completed it was pumped full of gas so that gas was delivered 6 days earlier than it could have been if the line had been left empty until completed.

A special section is carried in this issue of *The Petroleum Engineer* giving complete information concerning the construction and operation of the big gas line.

▸ **LINE FOR MEXICO.** Gas Industrial de Monterrey is making plans for a 140-mi. 14-in. natural gas transmission line from Rey Nosa to Monterrey, Mexico. Said to be financed by Mexican capital, the project is to increase fuel supply from Texas to Monterrey.

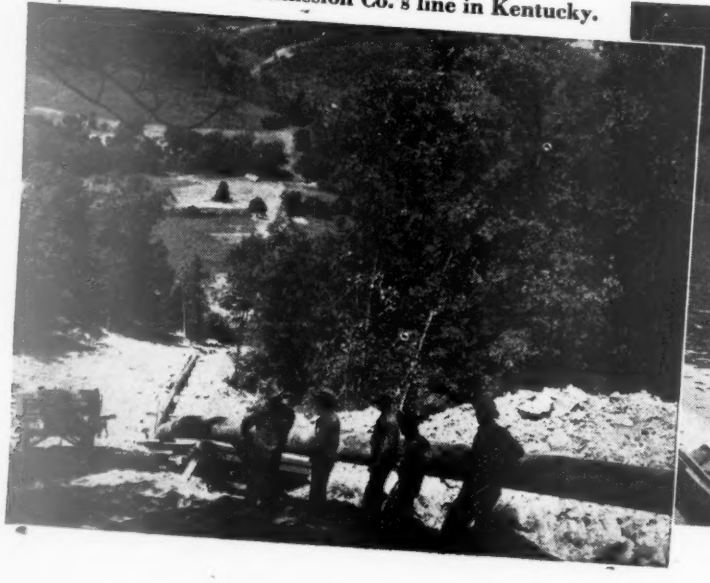
▸ **FINISH SURVEY.** Lone Star Gas Company has completed preliminary survey for a 105-mi. large-diameter natural gas line from the Trinidad Junction of its East Texas gathering system to the Carthage gas field of Panola County. Recently the company paid $800,000 to Rogers Lacy of Longview for gas from his producers in the Carthage area. Lone Star Company will move a natural gasoline and rectifying plant which it owns jointly with Lacy in the Willow Springs pool of Gregg County to the Carthage field where the Carthage gas will be processed before being turned into the lines. The plant has a capacity of approximately 50,000,000 cu. ft. daily. The Carthage field, which produces from the Pettit lime of the lower Trinity, is indicating the second largest gas reserve in the state, second only to Panhandle field.

▸ **TEXAS LINE.** Eastern Construction Company is expected to begin this month to lay approximately 32 mi. of 20-in. and 12-in. pipe line to transport gas in the Borger-Pampa area of the Texas Panhandle to serve carbon-black plants of Phillips Petroleum Company.

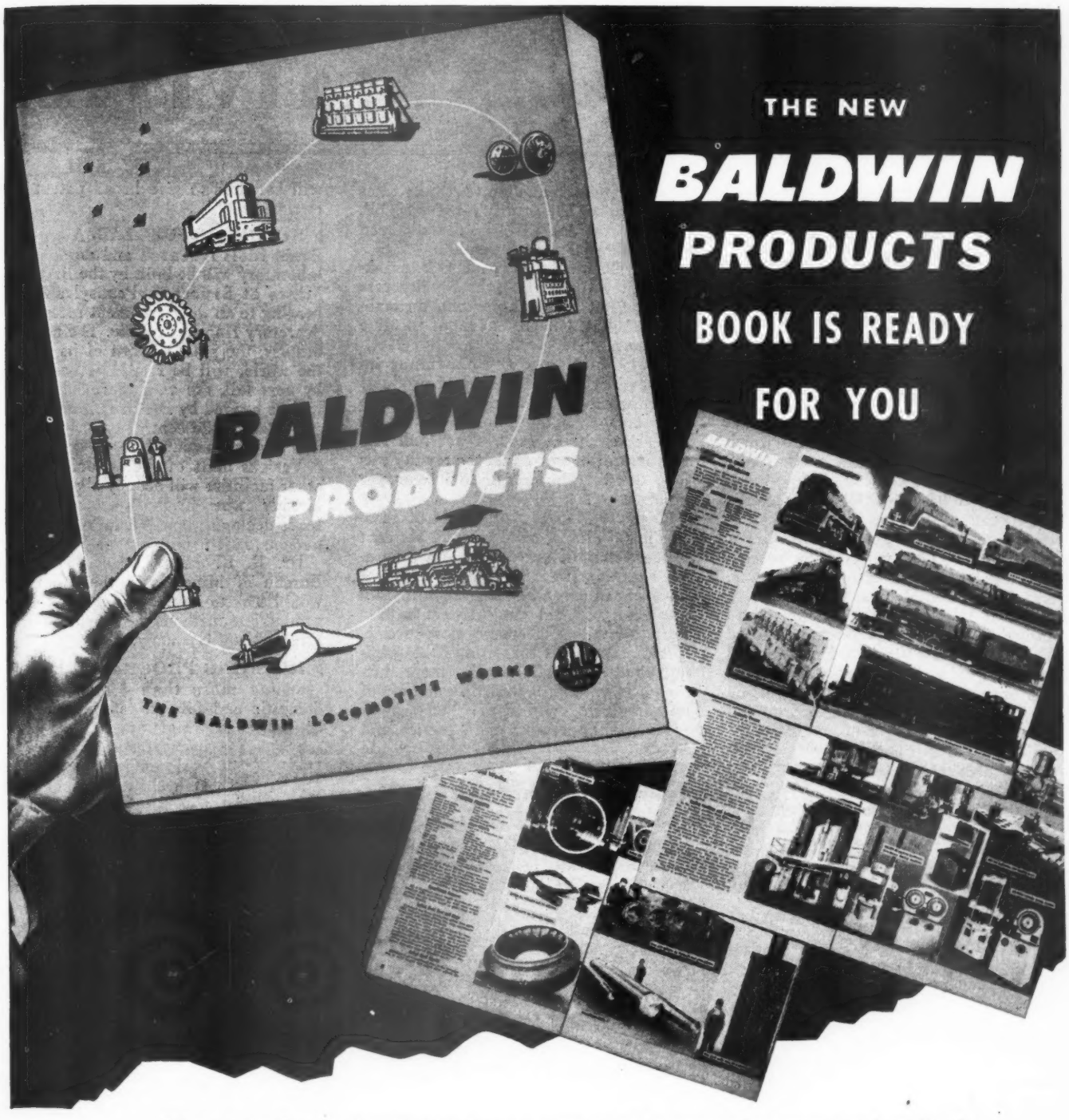
▸ **SEEK PERMITS.** The Cities Service Gas Company has petitioned the Federal Power Commission for permission to construct an additional pipe line from Shidler, Oklahoma, to Washington County, Oklahoma. This new 48 mi. 16-in. line would make it possible to increase the flow of gas from the big Hugoton field into Kansas City by 45,000,000 cu. ft. daily, the company said. It now supplies Kansas City with 125,000,000 cu. ft. of gas per day.

Government approval of a $60,000,000 pipe line to carry natural gas from Texas to southern California is being sought by three California gas companies. Plans for the project were disclosed by the Southern California Gas Company, the Southern Counties Gas Company, and the Pacific Gas and Electric Corporation. The line will start in the Panhandle and Hugoton field in Texas, extend through New Mexico and Arizona, and end at Los Angeles.

Tennessee Gas & Transmission Co.'s line in Kentucky.



Fixing charge to blast Cumberland River, Tennessee.



There is hardly an industrial field that does not use one or more of the many products listed and pictured on the pages of this new Baldwin bulletin. Between its covers you may find ways that Baldwin can help you with your immediate production problems or with your post-war plans.

A handy index of all the major products of The Baldwin Group, arranged in accordance with their applications in particular industries, will enable you to see at a glance where Baldwin can be of service. A request for Bulletin 211, on your regular letterhead, will bring this book to your desk without obligation on your part.

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MAJOR *Refining* ACTIVITIES

REFINERIES TO CAPACITY. Delay in consumer purchases of heating oil has caused a bottleneck in the movement of oil products and has filled refinery storage space, Ralph K. Davies, deputy petroleum administrator, has announced. Failure of consumers to purchase winter supplies of fuel now has "caused a backing up to a point where refineries are without sufficient storage for finished products," Davies said. Driver shortages, a limited number of trucks and tires, and the unpredictability of the weather increased the unpleasant prospects which tardy consumers may face, he declared.

CARBON BLACK PLANTS. Defense Plants Corporation has announced plans for construction of two carbon black plants of the Channel type to be constructed in Ector County, West Texas. The plants, 6 miles west of Odessa, will be built by DPC and then leased to United Carbon Black Company, Inc., of Charleston, West Virginia. Facilities will include 3 pipe lines, carbon gathering and gas systems and employes' housing project. Construction on the plants will be begun at an early date, the corporation said. An appropriation of $500,000 has been made to cover materials, machinery, and equipment.

REFINERY TO WEST EDMOND. Large scale expansion of the West Edmond oil field as a source of oil and gas has caused Denver Producing and Refining Company to order its idle refinery at Gainesville, Cook County, North Texas, dismantled and removed to a point on the Santa Fe right of way at Edmond. It is a 1500 bbl.-a-day skimming plant, and when rebuilt will probably include a cracking unit, so as to be able to obtain successfully as many of the by-products of the West Edmond crude as possible. The plant was designed originally to process North Texas and southern Oklahoma crude and supply fuel oil to the Texas lines of the Santa Fe, but supplies have proved insufficient, and the plant has been shut down for some time.

REDUCES ROYALTY. Universal Oil Products Company has announced, effective November 1, 1944, the third reduction of royalty rates in its history. The royalty rate for U.O.P. thermal cracking will be 3 cents instead of the previous 5 cents per bbl.

In 1922, when the first U.O.P. cracking unit was installed the royalty rate was fixed at 15 cents per bbl. throughput and a yield of 21 per cent of gasoline was guaranteed.

By 1934, despite the enormous increases in yield and quality of products the royalty was lowered one-third or to 10 cents per bbl. Again in 1938—just 4 years later, the process was still further improved and again the royalty was cut; this time in half, or to 5 cents per bbl.

From 1922 to 1944 the yield of gasoline has been increased from 21 per cent to more than 60 per cent on a comparable charging stock, services to licensees have expanded, while the royalty rate has been reduced from 15 cents to 3 cents a bbl.—an 80 per cent reduction.

This represents three times the original yield of gasoline, while the reduction in royalty has been to one-fifth of its initial rate.

Universal will give more service and will continue to give broad patent protection.

SYNTHETIC FUEL LAB. A synthetic liquid fuels research and development laboratory will be built by the Brueau of Mines at Bruceton, Pennsylvania, according to an announcement recently by Secretary Harold L. Ickes. The new laboratory, the most modern of its type in the world, will be ready for occupancy by next fall, the announcement said. It will be headed by Dr. H. H. Storch, now stationed at the central experiment station at Pittsburgh.

Various units of the laboratory and other facilities will occupy about 7 acres already owned by the Bureau of Mines, Ickes declared. It will employ about 280 persons, half technical personnel.

Dr. R. R. Sayers, director of the Bureau of Mines, said the laboratory would seek to improve on synthetic fuel production methods now employed in England and Germany.

REFINING PROGRAM. Plans for spending more than $350,000,000 on domestic and foreign refining facilities as soon as materials are available have been drawn up by the petroleum industry in the United States, according to a recent announcement by Deputy Petroleum Administrator Ralph K. Davies. The expense will include materials both for refineries here which have suffered from lack of replacements due to war restrictions and priorities and for foreign plants which have been wrecked by enemy action.

The planned expenditures amount to $176,789,385 for domestic refinery construction and $176,155,000 for foreign developments and replacements. The latter figure, Davies pointed out, does not include any estimate for the rebuilding of facilities in areas now enemy-occupied.

In a letter to WPB Davies said that oil refinery operations have been increased by "some 800,000 bbl. of crude daily. This increase," he continued, "has been accomplished with a minimum of new construction and much of the overload has been handled by prewar facilities."

Petroleum war plants to be disposed of by the Defense Plant Corporation

Negotiations for purchase or lease of properties listed will be entered into, subject to contingencies of present contracts and length of time plants will continue in war use.

State	Plancor No.	Operating company	Location	Area, sq. ft.
Arkansas	1530	Lion Oil Refining Company	El Dorado	12,000
	689	Root Petroleum Company	El Dorado	37,000
California	912	Wilshire Oil Company	Norwalk	21,500
	1593	Standard Oil Company of California	El Segundo	28,300
	1041	Mohawk Petroleum Corporation	Bakersfield	29,000
	963	Shell Chemical Company	Torrance	66,800
Kansas	959	Cooperative Refinery Association	Coffeyville	19,000
Kentucky	1067	Ashland Oil and Refining Company	Catlettsburg	91,900
Louisiana	1065	Standard Oil Company of Louisiana	Baton Rouge	1,900
	1526	Standard Oil Company of Louisiana	Baton Rouge	11,500
	592	Premier Oil and Refining Company	Cotton Valley	23,900
	706	Cities Service Refining Corporation	Lake Charles	25,100
	152	Standard Oil Company of Louisiana	Baton Rouge	65,000
	572	Standard Oil Company of Louisiana	Baton Rouge	191,000
Ohio	1365	Sun Oil Company	Toledo	38,600
Oklahoma	1036	Anderson-Prichard Refining Corp.	Cyril	2,200
	882	Continental Oil Company	Ponca City	2,500
	1042	Continental Oil Company	Ponca City	41,200
Pennsylvania	1044	Pennzoil Company	Oil City	19,900
Texas	1505	Southport Petroleum Company of Delaware	Texas City	2,100
	638	Great Southern Corporation	Bishop	4,700
	638	Great Southern Corporation	Agua Dulce	5,400
	638	Great Southern Corporation	Driscoll	5,900
	1534	Eastern States Petroleum Company, Inc.	Houston	11,700
	1571	Taylor Refining Company	Corpus Christi	12,100
	938	Magnolia Petroleum Company	Beaumont	13,600
	562	Pure Oil Company	Smiths Bluff	14,800
	1518	Humble Oil and Refining Company	Ingleside	19,200
	718	Republic Oil Refining Company	Texas City	23,400
	911	Eastern States Petroleum Company, Inc.	Houston	24,400
	638	Great Southern Corporation	Corpus Christi	24,500
	1068	Crown Central Petroleum Corporation	Houston	27,300
	1537	Humble Pipeline Company	Houston	33,000
	591	Southport Petroleum Company	Texas City	35,000
	485	Humble Oil and Refining Company	Baytown	61,600
	880	J. S. Abercrombie Company and Harrison Oil Company	Sweeney	74,900
	933	Neches Butane Products Company	Port Neches	100,800
	484	Phillips Petroleum Company	Borger	162,600
	1082	Humble Oil and Refining Company	Baytown	193,000
Utah	1164A	Utah Oil and Refining Company	Salt Lake City	58,400
Wyoming	1146	Frontier Refining Company	Cheyenne	47,700

THE Petroleum Engineer

NOVEMBER, 1944

PRODUCING DUAL COMPLETION OIL WELLS

By **C. C. PRYOR,** *Associate Editor*

EXCLUSIVE PRODUCTION of dually completed oil wells is often a difficult operation when the upper zone cannot be produced successfully through the annular space. This difficulty, which results in lost lifting power, is caused by the large cross-sectional area of the annulus reducing the velocity of flow and by gas breaking out of solution with the oil due to expansion in the annular space and the friction on the outside of the tubing and inside of the casing. The cooling effect that results from the gas breaking out of solution is also a direct cause of paraffin formation in the low temperature area and thus requires the use of paraffin knives, chemicals, or heated oil for removal.

These problems facing the operators have been overcome to a large extent by the developments in dual completion production methods and equipment, whereby the upper zone is produced through the tubing and the lower and higher pressure zone is produced through the annulus. A sketch of the bottom-hole equipment used in the method herein described is shown in Fig. 3. The main item of equipment is the change-over flow tube that transfers the flow of oil from the bottom zone around the perforations of the upper zone and into the annular space. Two packers are used in the method. One is set above the upper zone and one between the two zones. Flow around the packers and through the change-over flow tube is indicated by arrows.

In a South Texas field a well was originally completed at a total depth of 5768 ft. in a sand, the top of which was found at 5744 ft. Casing set at 5768 ft. was perforated with 34 shots between 5759 ft. and 5765 ft. The operators decided to dual complete the well by bringing in a shallower sand found between 5583 ft. and 5269 ft. Accordingly, the lower sand was killed with mud and a bridge plug set at 5740 ft. Then the 5½-in. casing was perforated at 5601 ft. to 5602 ft. with six shots and squeezed with 75 sacks of cement at the oil-water contact. After the plugs were drilled, dry drillstem tests showed that both squeezes were successful. Thirty shots were then used in perforating the section between 5593 ft. and 5598 ft. The drillstem tests produced oil and gas. Then the bridge plug set at 5740 ft. was drilled out and a casing scraper run to condition the casing after perforating and drilling.

Both packers used in the well were of the retainer production type. The lower or interzone packer was a retainer production type with continuous double seal and the upper packer a retainer production type with a packing head seal. The lower packer was run into the well on a setting sub to a depth of 5730 ft. for setting. The setting sub was made up on the packer at the well and connected to the running-in string by an expansion joint. When the setting depth was reached a tripping ball was dropped into the running-in string and pumped down to the packer tripping ball seat unit. This operation is shown in Fig. 1. Seating of the ball in the unit in the packer closed circulation through the packer and the operator proceeded to set the packer by increasing the pump pressure to force fluid out through ports in the packer and under the packing element. When the packing had been expanded until it contacted the casing, additional fluid pressure caused it to

Fig. 1

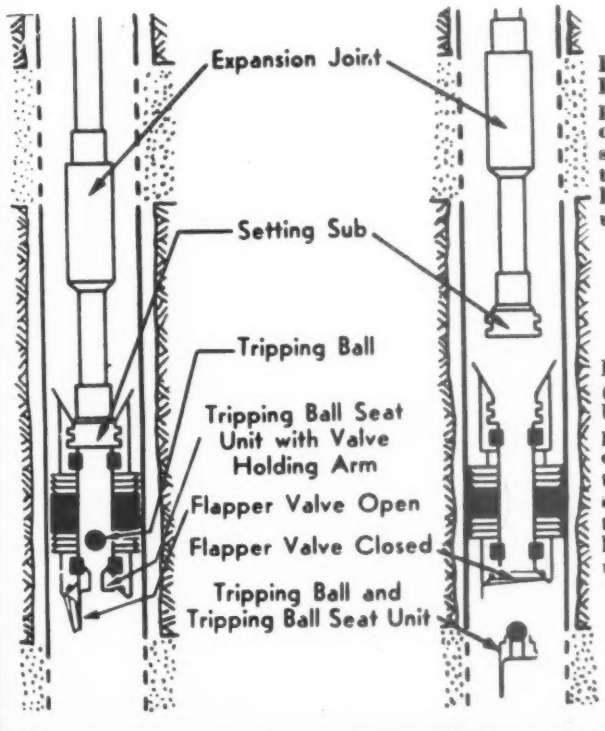
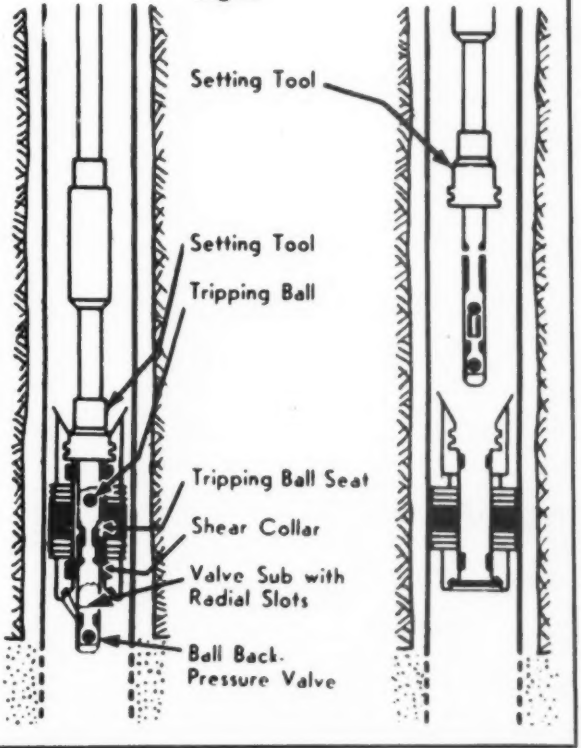


Fig. 1 *(left)* Lower packer run on setting sub with tripping ball seat unit.

Fig. 2 *(right)* Upper packer run on setting tool without tripping ball seat unit.

Fig. 2



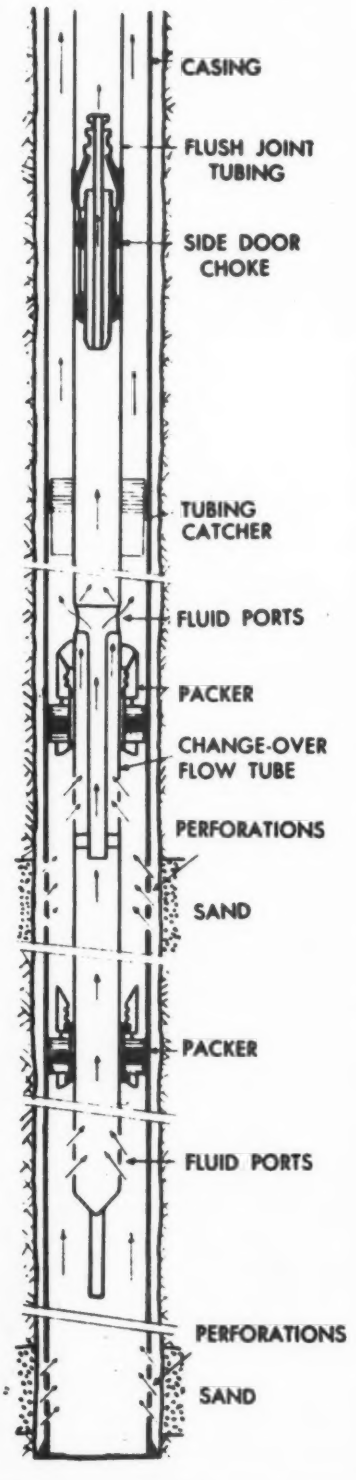
elongate and shear screws that held the upper cone to the packer body and the upper slips to the cone. Continued pressure raised the cone and forced the slips out to the casing wall for an initial set. Pump pressure required for the upper slips was about 750 lb. per sq. in.

After the upper slips had made an initial set, pump pressure was slowly bled back to 250 lb. per sq. in. and a strain taken on the running-in string that caused the upper slips to grip the casing for a permanent set, preventing further upward movement of the packer. An increase of the tension taken on the running-in string moved the body of the packer upward in the packing assembly and sheared the screws that held the lower cone to the body of the packer and the slips to the cone. This action caused the slips to slide down and out off the cone and engage the casing wall to prevent downward movement of the packer. Additional tension on the running-in string compressed the packing and completed the operation. The tension was applied to the running-in string while the pump pressure was bled down to allow the fluid to bleed from the packing and the packing to assume shape. Then the pressure was increased sufficiently to shear the screws holding the tripping ball seat in the bottom of the packer and allow the unit to drop down the hole. This action left the packer set and the hole open for tubing to the bottom. Back pressure was held on the lower zone by the flapper valve shown in Fig. 1 on the bottom of the packer. The tension on the running-in string was then released and the setting sub with left-hand square threads connecting it to the packer was backed off and the string pulled from the hole.

Although the setting of the interzone packer is accomplished easily by means of the tripping ball seat unit, the fact that the seat and ball are forced from the bottom of the packer by pressure and drop into the hole makes this method of setting undesirable for the upper packer. This is due to the tripping ball seat unit lodging in the interzone packer opening and obstructing the tubing later run into the well.

The second or upper packer in this well was set at 5565 ft. and, as previously mentioned, was a retainer production packer with a packing head seal. The method of setting this packer is shown in Fig. 2. A setting tool was made up on the packer in the shop before delivery to the well by removing the tripping ball seat unit and cutting the shear screws off so that they did not protrude beyond the inside diameter of the packer. The packer was run into the well on an expansion joint to 5565 ft. and setting operations were begun. A tripping ball was dropped into the running-in string and pumped to its seat in the setting tool. As the pump pressure was increased the screws were sheared that held the tripping ball seat, which covered the fluid ports as a sleeve, and forced it downward to rest on the shear collar, thus uncovering the fluid ports, but still preventing circulation through the setting tool. This action permitted fluid to be forced through the fluid ports of the setting tool and through the fluid ports of the packer. Fluid entered beneath the packing, expanding it to the wall of the casing. Elongation of the packing under pressure sheared the screws holding the cone and slips and permitted the slips to engage the casing. A strain on the running-in string set the slips and prevented further upward movement of the packer. This procedure was the same as that used for setting the slips in the interzone packer and was followed in engaging the lower slips.

Fig. 3. Dual completion utilizing a change-over flow tube to produce upper sand through the tubing.



When the packer had been set pressure was again applied and the screws sheared that held the shear collar. The shear collar and the tripping ball seat unit dropped down into the enlarged section of the setting tool on the valve sub as shown in the left-hand sketch of Fig. 2. Fluid was then permitted to pass downward through the setting tool. The running-in string was then relieved of tension and the setting tool made up to the packer with left-hand square threads backed off and pulled out of the hole. The flapper valve on the bottom of the upper packer prevented flow of the upper sand through the packer. These flapper valves prevent flow of the sand when tubing is pulled through the packer after the sands have been brought in.

After the packers had been set, the change-over flow tube was made up on the string of production tubing with a side door choke nipple in the string 30 ft. above the top packer, Fig. 3. The tubing string, 5748 ft. in length, was run into the well through the two packers and landed with the fluid ports of the change-over flow tube just above the upper packer packing sub. After the tubing had been landed the well was washed in with water and cleaned and the side door choke set in the choke nipple. Preparations were then made for testing.

The change-over flow tube provides for production of the two zones simultaneously. It consists of a welded tee in the upper portion of the outer tube, Fig. 3, with the vertical leg of the tee or inner tube extending down the inside of the outer tubing section with a seal near its lower end. The outer tubing section is perforated above and below the seal around the inner tube. Production from the lower sand enters the fluid ports near the bottom end of the outer tube and flows up through the inner tube to the tee and out into the annular space. Thus production from the lower sand is flowed around the two packers to the annulus and then to the surface. Fluid from the upper sand, which is the weaker sand and will not flow through the annular space, enters the outer tube through the perforations above the inner tube seal above the interzone packer and flows up through the annular space between the inner and outer tube, around the tee and thence to the surface through the tubing.

When the well was tested the lower sand produced 94 bbl. of 30.5 gravity crude oil per 24 hr. with a gas-oil ratio, cu. ft.: bbl., of 368:1 and the upper sand produced 92 bbl. of 30.8 gravity per 24 hr. with a gas-oil ratio, cu. ft.: bbl., of 450:1. The oil in the upper sand has a relatively high paraffin content and is deposited where the pressure drop due to gas expansion is greatest. The change-over flow tube provides easy access to this area, as the upper sand is produced through the tubing. Although the upper sand does not have sufficient lifting power to be produced through the casing, the reduced cross-section of the tubing permits flowing production. ★ ★ ★

CONTINUOUS AUTOMATIC ETHYL BLENDING FACILITIES

By **JOHN H. KUNKEL,**
Refinery Editor

EXCLUSIVE A LITTLE more than a year ago, the sun Oil Company installed a 60-ton continuous automatic loss-in-weight Ethyl fluid blender in its Toledo, Ohio, refinery. In addition to the unit's features and the method by which it performs the blending operation, the installation is interesting on two counts. Although this type blender has been installed in a number of refineries as replacement for existing batch-type Ethyl blenders, the Sun Toledo installation marked its first application in a refinery where gasoline had not been previously leaded, and this particular installation proved to be the solution to a definite location problem.

John H. Kunkel

At the Toledo refinery, the objective was to add tetraethyl lead proportionately to motor gasoline in amounts ranging from 0.5 cc. to 1.5 cc. per gal. Sun and Ethyl Corporation engineers conferred to determine the most efficient and economical method of achieving this result in the light of conditions existing at Toledo.

The unleaded gasoline is pumped from refinery production tanks at the rate of 700-1200 gal. per min. through an 8-in. line to the automatic Ethyl fluid blending unit, then to field storage tanks situated more than a mile from the refinery area. The distance referred to and the presence of the existing 8-in. line from the transfer pumps to the storage tanks were major factors that dictated the installation of the continuous automatic loss-in-weight blender.

The storage area lacked the necessary facilities for the installation of the conventional batch-type blender. In addition, because the storage area is more than a mile from the refinery, such a site was inconvenient for operating personnel. On the other hand, had a conventional batch blender been situated in the refinery area, a considerable amount of additional piping would have been required to provide the necessary recirculation lines between the batch blender and the blending and the field storage tanks. Operating costs, likewise, would have been increased by the extra pumping costs. As the continuous automatic loss-in-weight blender could be installed on the existing 8-in. line without the addition of extra piping and, at the same time, placed the Ethyl blending plant in the refinery area where it would be accessible to control personnel, the engineers selected it as the solution to the problem existing at Toledo.

▸ **The loss-in-weight blender.** The continuous automatic blender is a development of % Proportioneers, Inc. %. It is a modification of the standard weight tank and eductor batch or manual unit developed by the Ethyl Corporation.

Sun Oil Company makes installation at its Toledo, Ohio, refinery, where gasoline had not been previously leaded, to solve a specific problem.

To the batch or manual unit equipment has been added to provide continuous automatic blending of gasoline with Ethyl fluid in any dosage from 0.2 cc. to 6 cc. of tetraethyl lead per gal. despite variation in the rate of flow of gasoline being treated.

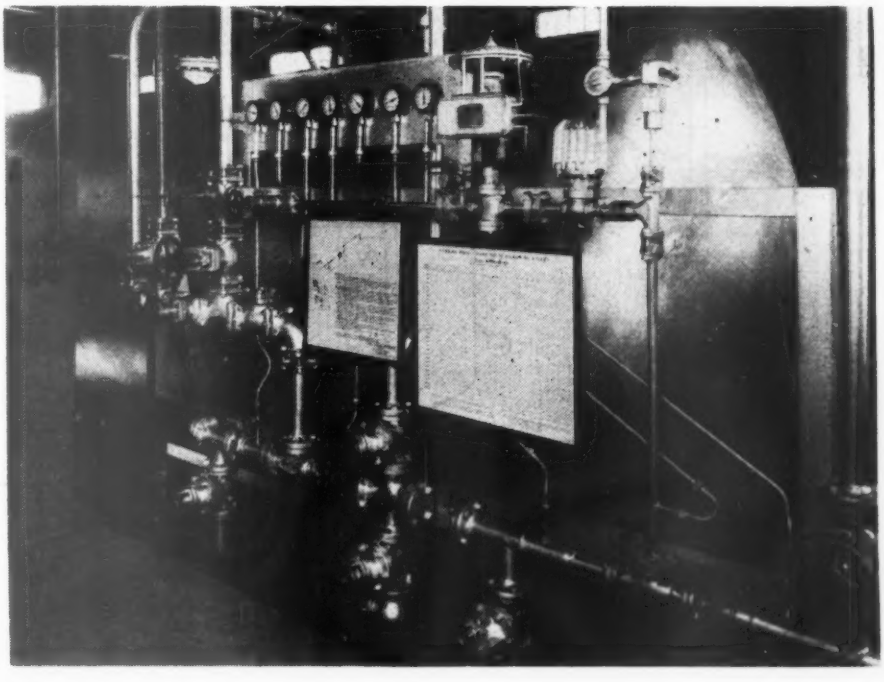
Briefly the equipment consists of the following:

1. An 8500-gal. horizontal Ethyl fluid storage tank mounted on a 60-ton, double beam scale.
2. A venturi meter tube and Chronoflo transmitter for measuring the rate of gasoline flow and transmitting it by means of a timed electrical impulse to a poise retraction mechanism.
3. A clutch assembly, drive mechanism and control instrument for retracting the poise weight on the graduated balance beam of the tank scale by means of a constant pitch screw at a rate proportional to the changing flows of gasoline through the venturi tube and based on a predetermined, and manually set, tetraethyl lead treatment in cc. per gal.
4. An air control system attached to the free end of the scale balance beam in such a way as to control the amount of air pressure exerted on the diaphragm of the control valve in the Ethyl fluid feed line and hence the rate of fluid evacuation from the weigh tank.
5. A system of safety devices and audible alarm signals. These are mounted on an instrument panel and light, with audible alarms sounding simultaneously, in case of eductor pump failure, air pressure failure, vacuum failure, "high" beam, or "low" beam.

In addition to the above instruments are gasoline and Ethyl fluid totalizers, both batch and continuous. The blender operates on vacuum.

▸ **Flow and operation.** Note: In the following description, the first numeral refers to the figure number and the second numeral or letter refers to the item in that figure as, (1-1) indicates reference to Fig. 1, item 1; or (2-F) indicates reference to Fig. 2, item F, etc.

Unleaded gasoline, from the refinery production tanks, is pumped through



View showing eductor manifold, control valve, Ethyl storage tank, and automatic loss-in-weight scale.

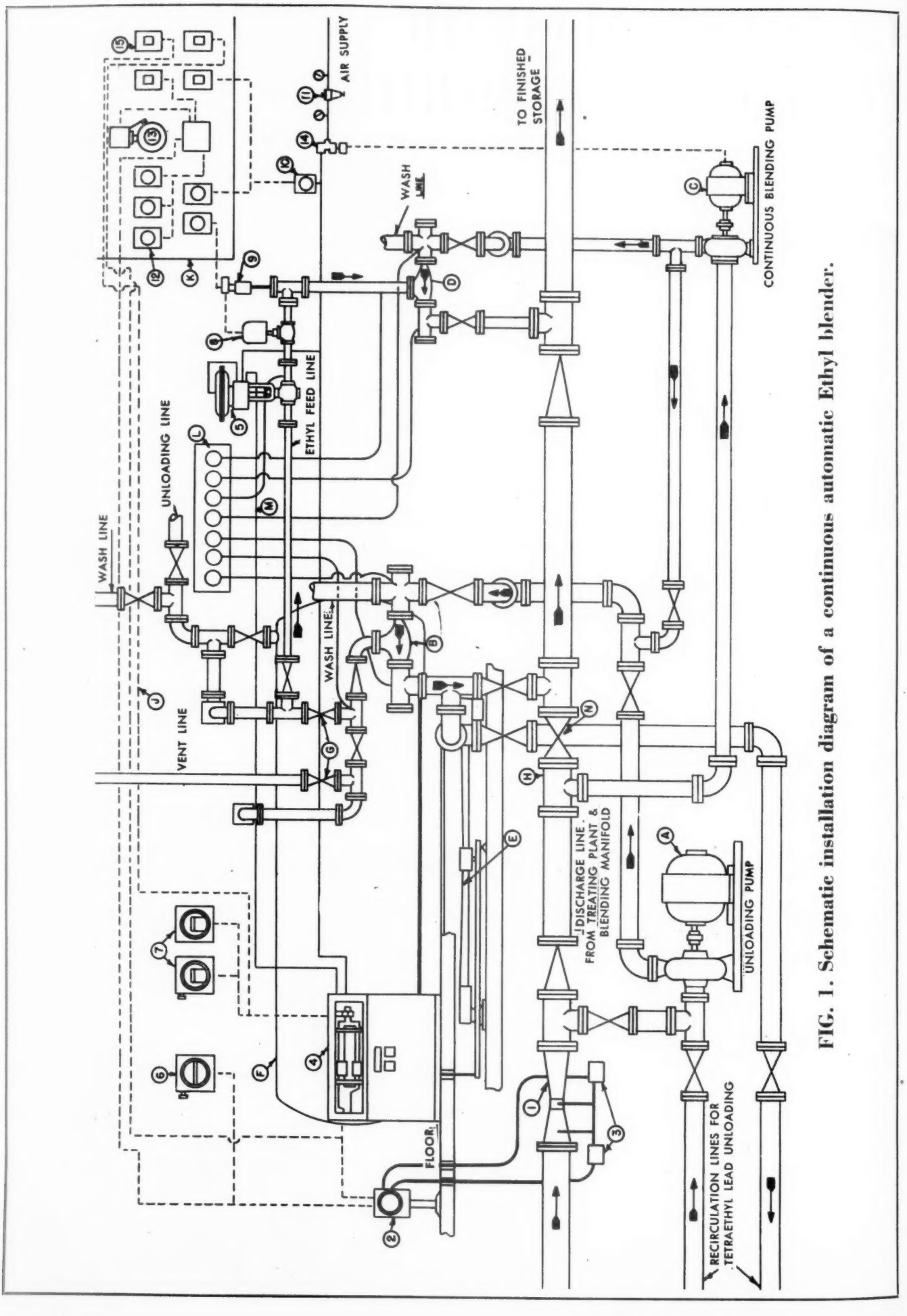


FIG. 1. Schematic installation diagram of a continuous automatic Ethyl blender.

the line to the Ethyl blending unit. A venturi meter tube (1-1) is installed in this line. A small eductor pump (1-C) takes suction on the gasoline stream just below the venturi tube from main gasoline line (1-H) and passes a portion of the stream through an eductor (1-D) where it picks up the exact amount of Ethyl fluid required for the blend in process from the weigh tank and returns it to the main stream whence it flows to the blending tanks or to field storage tanks.

The venturi tube is tapped for pressure piping connections, a high pressure line leading from the inlet and a low pressure line coming off from the venturi throat. The high and the low pressure lines pass through seals (1-3), which contain a liquid transfer medium transmitting the venturi tube pressures to high and low pressure mercury wells attached to a Chronoflo transmitter (1-2).

The difference in the pressure at the venturi tube inlet and that at the throat establishes a differential that measures the rate of gasoline flow at all times, as the rate of flow is proportional to the square root of the differential pressure. Changes in the rate of flow affect the level of a float in the low pressure mercury well that regulates the operation of the Chronoflo transmitter.

The function of the Chronoflo transmitter is to convert the rate of gasoline flow into a series of timed electrical impulses that actuate the mechanism regulating the rate at which Ethyl fluid is withdrawn from the weigh tank (1-F) thus maintaining the desired cc. per gal. treating ratio despite changes in the rate of gasoline flow.

Electrical impulses from the Chronoflo transmitter also actuate a motor-driven, 11-figure gasoline totalizer (1-6) mounted on the instrument panel. This totalizer registers the amount of gasoline flowing through the venturi tube. Five of its 11 figures may be reset at the start of each blending operation.

The Chronoflo transmitter. Essentially, the Chronoflo transmitter consists of a telechron motor-driven cam, a rocker bar and magnet, and a cam shoe on the rocker bar arm. The mechanism is housed in an explosion-proof case.

In operation, the transmitter cam shoe rotates at a constant speed, making one revolution every 15 sec., or 4 r.p.m. The cam shoe swings in a plane parallel to the face of the cam between the cam and the rocker bar. As the leading edge of the cam lifts the cam shoe the rocker bar is moved outward, carrying the magnet away from a mercury switch, causing the switch contacts to close.

Control of the length of time that the cam shoe rides on the cam face is by means of an arm from the float in the low pressure mercury well. Any increase or decrease in differential pressure causes the float to rise or fall, establishing the length of time of contact of the shoe against the cam face, thus governing the length of time that the mercury switch remains closed and the duration of the electrical impulses transmitted to

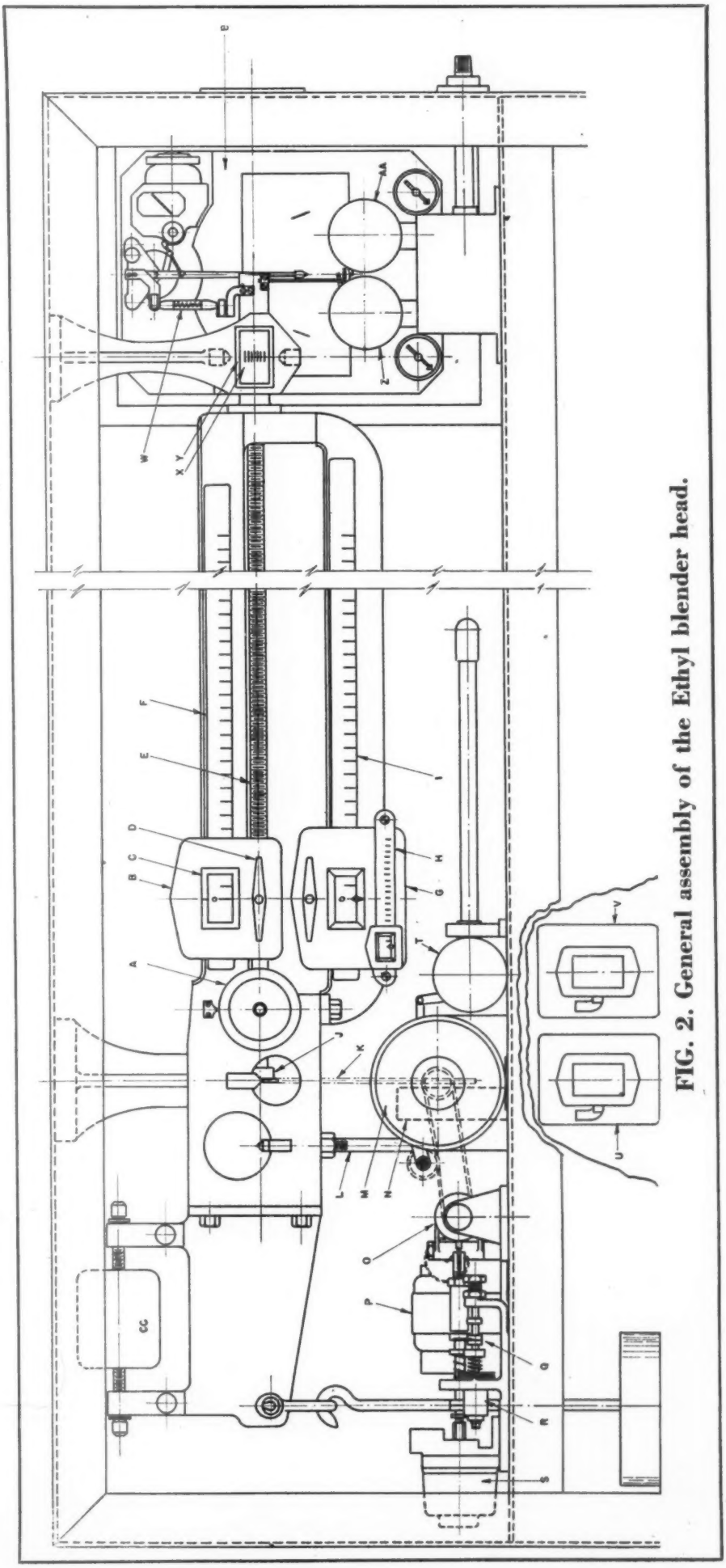


FIG. 2. General assembly of the Ethyl blender head.

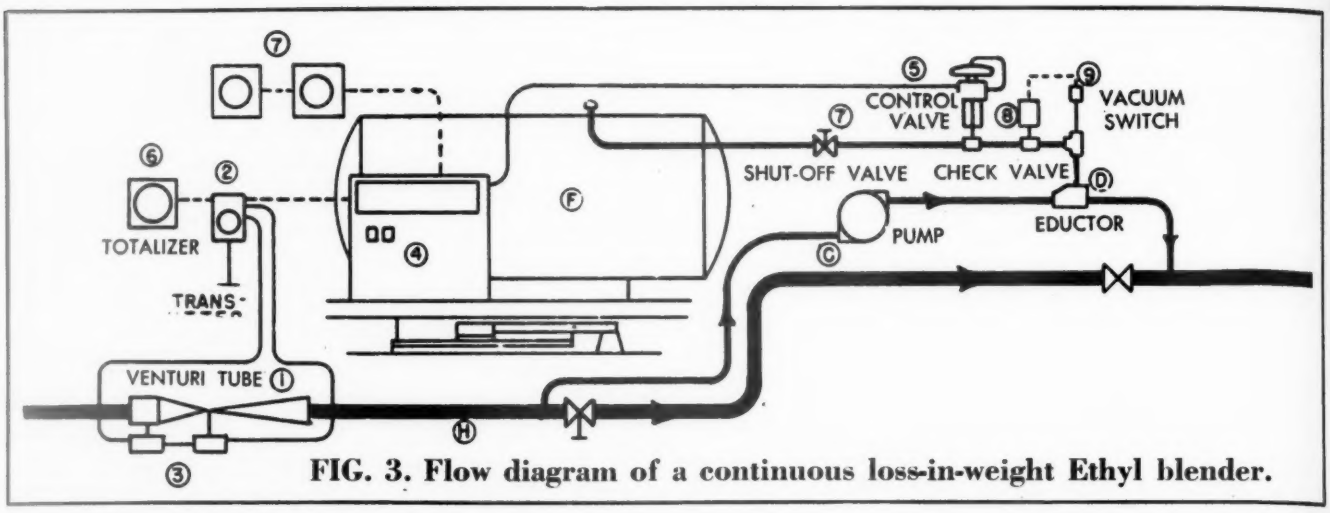


FIG. 3. Flow diagram of a continuous loss-in-weight Ethyl blender.

the mechanism regulating the flow of Ethyl fluid from the weigh tank.

The cam is so designed that, at maximum, the cam and shoe will have a contact of 13.33 sec. out of each 15-sec. period and will vary to a minimum contact of 0 sec. at 0 gasoline flow through the venturi tube. The design of the cam is such that the square root function of the rate of flow is removed, as the time of contact of cam and shoe is a direct measure of flow in gal. per min.

▸ **The scale beam mechanism.** The scale beam, poise assembly, and operating mechanism are enclosed in a welded steel cabinet with hinged glass inspection window. The cabinet protects the scale beam and control assembly from stray air currents that would disturb the balance. The cabinet also protects the mechanism from dust and dirt. It may be locked to prevent tampering by unauthorized persons. The loss-in-weight control scale (1-4) is equipped with a double beam. Each beam has a capacity of 60,000 lb. A constant pitch, super-accurate poise screw (2-E) runs the full length of the upper beam (2-F). The movable poise (2-B) on this beam has a split nut built into it to engage the screw so that, as the screw is turned, the poise will be retracted. The lower beam (2-1) also has a movable poise (2-G) with an additional small balancing scale (2-H) to enable the operator to bring the scale into exact balance with the Ethyl fluid weigh tank.

The poise screw drive mechanism is built into the scale cabinet and consists of a fractional horsepower drive motor (2-P), a solenoid operated clutch (2-0), a speed changer (2-M), and a gear reduction unit (2-N). The poise screw is driven by a chain and sprocket drive (2-K) from the output of the gear reducer. The cabinet also houses a microswitch (2-T), which actuates the two Ethyl fluid totalizers mounted on the instrument panel. The outboard end of the scale beam is connected to the operating linkage (2-W) of an air controller, which is also built into the cabinet.

The air controller consists of three principal units: A free-vane unit, a sensitivity adjustment unit, and a bellows unit. The free-vane unit is connected to the outboard end of the scale beam by a light link (2-W). Movement of the scale beam causes a repositioning of this free-vane, which, in turn, transmits an impulse to the bellows unit and from there to a valve positioner on the Ethyl fluid control valve.

Control switches (2-U and 2-V), for opening and closing the drive motor and clutch solenoid circuits, respectively, are mounted on the front of the cabinet. "High" beam (2-AA) and "low" beam (2-Z) alarm switches are mounted in the righthand end of the cabinet and are actuated by a linkage from the outboard end of the scale beam.

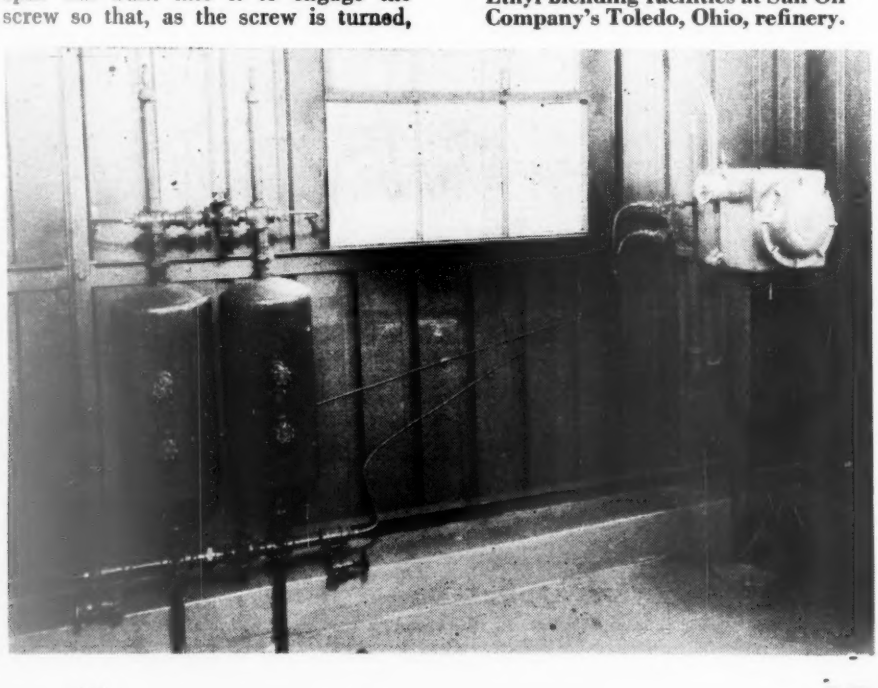
▸ **Scale beam operation.** The Chronoflo transmitter sends a signal to the solenoid in the clutch drive assembly. The drive motor runs continuously and drives the poise screw by means of a solenoid-operated disk clutch.

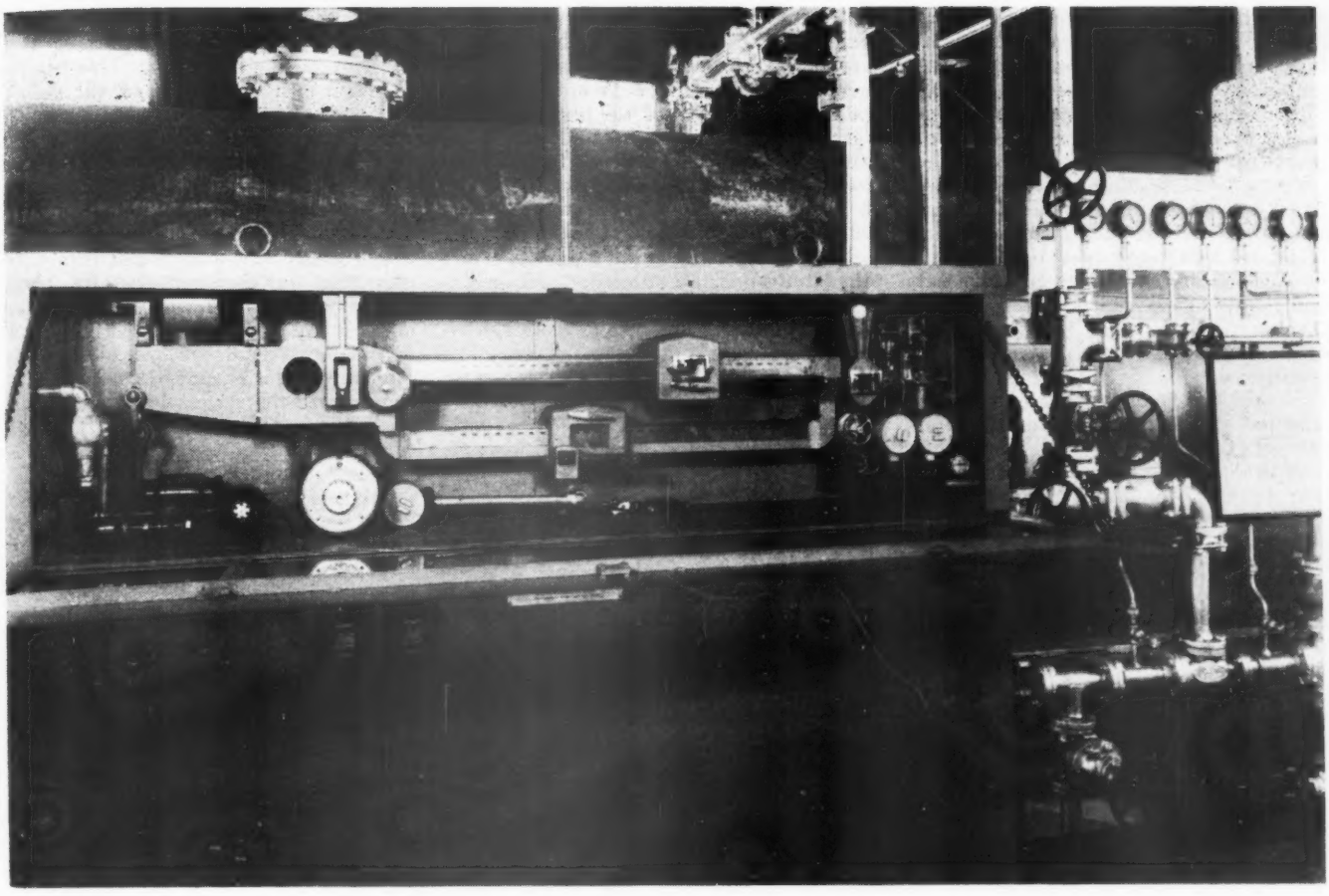
When the Chronoflo transmitter cam shoe is on the cam (the "on" period) the solenoid is energized and the clutch closes, the throw of the solenoid, by compressing a spring, supplying the force that closes the clutch faces. For greater driving power, the clutch faces are ring-type. To prevent slamming of the solenoid core, and to provide full adjustment, an air dash-pot with an adjustable linkage is positioned beside the solenoid to provide spring cushioning and return.

As the "on" period of the Chronoflo transmitter will vary exactly in proportion to the rate of flow of gasoline through the venturi tube, the amount of drive transmitted through the clutch is the measurement of flow. The r.p.m. of the motor is transferred by means of a chain and sprocket drive to the input shaft of the speed-changer. This device permits infinite ratios of from 1:1 to 100:1 between the input and output shafts.

From a speed-changer calibration curve, the operator can obtain any desired degree of tetraethyl lead treatment, from 0.2 cc. per gal. to the required maximum by selecting the proper speed-changer setting. The output of the speed-changer becomes a product of the flow measurement, modified by the desired treatment necessary to treat the flow at that minute at the set dosage.

Chronoflo transmitter and seal pots in the continuous automatic Ethyl blending facilities at Sun Oil Company's Toledo, Ohio, refinery.





Front view of %Proportioneers% automatic loss-in-weight scale and cabinet for tetraethyl lead.

The output of the speed-changer is further reduced by the gear reduction unit and then carried by vertical chain to the sprocket mounted directly on the end of the poise screw and exactly in both planes of the beam fulcrum. Although this drive is intermittent, to the extent of 4 cycles per min., the effect on the scale, for all practical purposes, is continuously to retract the weight each minute by exactly the weight of lead called for that minute.

The face plate on the scale beam is marked in 100 lb. increments and the vernier dial (2-A) is geared 1:1 with the retracting screw so that the graduations on the vernier dial provide a means for reading the momentary position of the upper poise weight to as close as 0.5 lb. by interpolating between the vernier graduations. In keeping the logsheet, the operator carefully notes, by means of a cross-hair and magnifying glass (2-X) and scale (2-Y) at the free end of the beam, that the beam is in true balance before noting the poise weight and vernier lead readings.

▸ **Ethyl fluid feed.** At the start of the blending process, the scale is in balance with the upper poise weights at the far, or free, end of the beam. As the poise screw rotates, the upper poise will retract along the beam. The Ethyl fluid is removed from the weigh tank by means of a small eductor (1-D) connected in the fluid manifold. This eductor creates a vacuum in the Ethyl fluid feed line, withdrawing the fluid from the weigh tank.

An increasing demand for tetraethyl lead flow, evidenced by an increase in the gasoline flow as transmitted to the poise retraction mechanism, tends to lighten the scale beam by retracting the poise at such a rate that the fluid withdrawn from the tank is not the equivalent in weight of the poise travel. This condition of unbalance causes the beam to move away from the horizontal, and this motion is transmitted to the air control (2-BB), which in turn allows more air to go to the diaphragm of the fluid control valve (1-5) and therefore allows the valve to open farther, thereby increasing the feed of Ethyl fluid until the scale is again in balance.

A small eductor pump (1-C), operating at constant rate, produces a constant vacuum and, as the control valve begins to open, more lead will flow from the weigh tank through the eductor. With the weigh tank losing lead more rapidly, the beam returns to its original "in balance" position.

▸ **Air control system.** The Ethyl fluid control valve is a normally closed diaphragm motor-operated valve with characterized plug and seat so arranged that air pressure is required to open it. This valve responds to the air controller and, by means of the valve positioners, it exercises a more exacting control on the valve stem travel. The positioner is mounted on the diaphragm valve to eliminate as much as possible any "hunting" by the valve as it changes position under impulses from the air controller. The positioner consists principally of a bellows and spring adjustment connected by a linkage to the control valve stem. It tends to eliminate hunting by exerting an upward force on the valve stem when the diaphragm exerts a downward force and vice versa.

As the operation proceeds, the movement of the upper beam poise toward the zero point will tend to lighten the beam. On the other hand, the suction at the eductor will draw Ethyl fluid from the tank tending to lighten the tank and thus make the beam heavy. Under theoretically perfect conditions, the lightening of the beam by the poise movement will maintain a constant uniform position with only slight and slow oscillation above and below the true balance position.

As the beam makes its oscillations, the movement is transferred to the air controller by the connecting link. The function of the air controller is to produce a change in controlled air-pressure exactly proportional to the magnitude of the change of beam position.

The measure of response of the controller is its sensitivity, which is the ratio of the output pressure change to the movement of the beam. High sensitivity results in a large output pressure change and low sensitivity gives a small output pressure change for a given beam movement. The sensitivity may also be interpreted to mean the ability of the controller to return the beam to exact balance within a longer or a shorter time, depending on the setting of the sensitivity unit to either low or high.

Sensitivity may be varied over any

range from 1 to 100 per cent throttling range. This adjustment is made by rotating a sensitivity adjusting knob on the air controller until a pointer corresponds to the selected sensitivity on the controller reading scale. Sensitivity values are in per cent throttling range and the setting should be adjusted to as high a point as possible to a small throttling range without introducing hunting. This is defined as a continuous oscillation of the scale beam about the control point and is due to too high a sensitivity adjustment. "High" and "low" positions are arbitrary and depend a great deal on conditions encountered.

Should the beam go out of balance with the sensitivity unit set on the high side, the air controller will react and tend to return the beam to normal position quickly. The lower the sensitivity, the longer will be the period before the air controller goes into action.

To help the Ethyl fluid control valve regain its balance point more quickly, a secondary or reset bellows has been incorporated into the mechanism to act as a damper. For example, an increase in the controlled air pressure will cause a contraction in the reset bellows. This in turn causes an expansion of follow-up bellows that react through differential levers to change the position of a free vane and thus counteract the air increase. By turning a reset valve knob, a leak port is allowed to open, which permits the escape of the air that was forced into the follow-up bellows. This allows the follow-up bellows to become balanced with atmospheric pressure on both the inside and outside, and the sensitivity is brought back to its original setting. Conversely, with a decrease in the controlled air pressure, air will bleed through the reset valve and establish atmospheric pressure on both sides of the follow-up bellows.

As the scale beam swings past the zero point on its oscillations, the air controller alternately causes the diaphragm valve to open and close. The movement of the valve is controlled accurately by the positioner. Air from the same line that supplies the controller is also connected to the positioner and is led to a pilot valve that controls the flow of air to the diaphragm of the control valve. The pilot valve is normally kept open by a lever acting on the control valve stem. Through this lever the pilot valve is operated jointly by the controlled air pressure and the valve stem movement.

Assuming that the positioner is in equilibrium, air will escape through an exhaust port and around the stem as fast as it enters the pilot valve. Should the controlled air pressure increase due to movement of the beam, spring-loaded bellows compress and move the left-hand end of the lever upward, thus opening the pilot valve wider, increasing the pressure on the diaphragm. This causes the stem to move downward, the downward movement being transmitted through a pin, link, and connecting rod to an arm. The right-hand end of the lever operating the pilot valve is pivoted to another lever that rotates on a stud as an axis. This latter lever is rotated by a bell crank and arm and it transmits movement to the control valve lever through a pin. The downward movement of the valve stem brings the right-hand end of the lever downward, closing the pilot valve. This change of positions continues until the system is once more in equilibrium with air pressure from the controller.

This floating action will always occur as the scale beam moves. The higher the air pressure, however, the farther past the balance point the diaphragm will be forced due to a greater inertia being present as the valve goes from "open" to "close" and vice versa. An optimum air pressure on the diaphragm will cause a damping effect that will, in turn, tend to return the valve to its balance point with a minimum of oscillation.

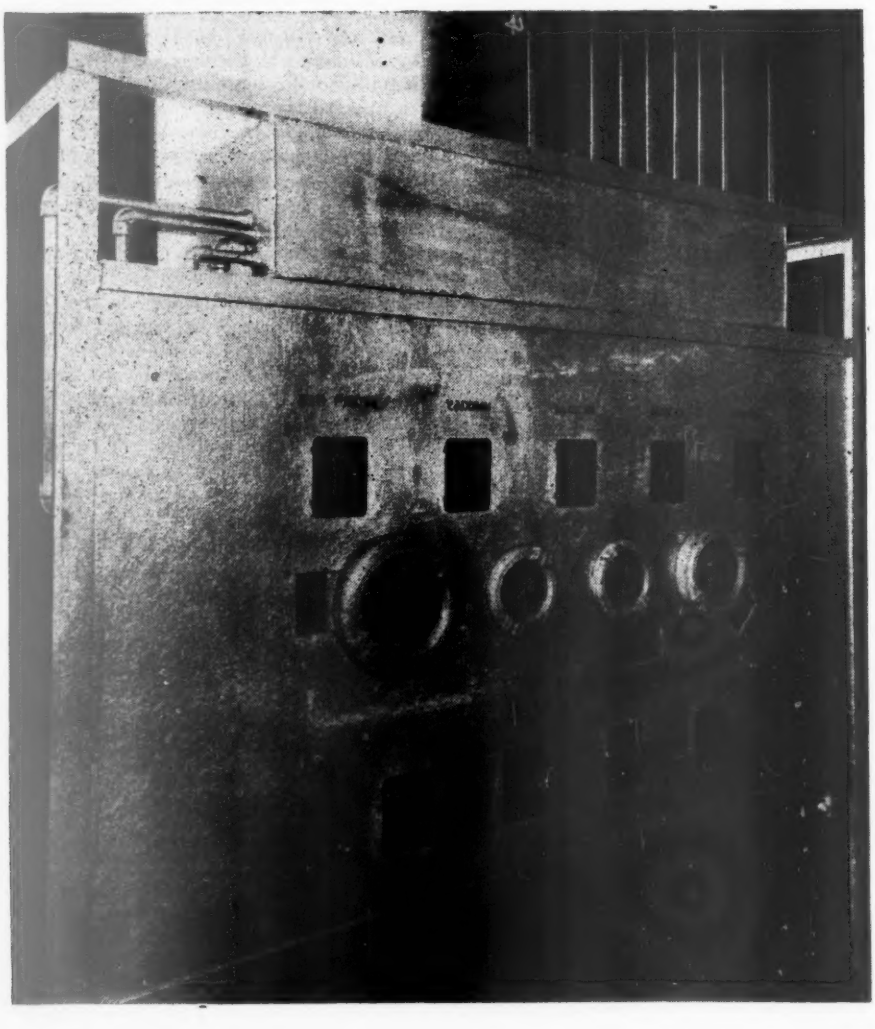
As the air controller acts to bring the beam back to a middle balance point, the positioner, through the controller, will always tend to return the valve to the same position from which it started. The only time the valve will change its position and remain changed is when the beam itself fails to come back to the point from which it departed.

The air controller is provided with sensitivity adjustments so that it is possible to vary the speed with which the control valve responds to a given motion of the scale beam and, in practice, it will be found possible to pick out the correct degree of sensitivity on the air controller for any given flow condition so that the scale beam, although continuously affected by two opposing unbalancing forces, will stay in balance.

With reference to the control air pressure, the greater the fluctuation of the rate of gasoline flow through the venturi tube, the greater will be the degree of sensitivity desirable in the controller. Proper operating conditions will find the scale beam continuously on balance point because this means that fluid is being withdrawn from the tank at exactly the rate necessary to treat the gasoline flow at the desired dosage, which means even, uniform treatment.

Incidental to the main drive assemblies of the scale, there is a linkage that serves to operate an explosion-proof micro-switch to give one electrical impulse for each pound of Ethyl fluid demanded. This impulse is carried to the two Ethyl fluid totalizers (1-7) mounted on the instrument panel. One of these is a continuous totalizer and the other a reset totalizer. These two totalizers with the reset portion of the gasoline totalizer, supply the operator with complete data on the gasoline flow and the number of pounds of Ethyl fluid added for individual runs.

▶ **Supervisory equipment.** The purpose of this equipment is to so completely



Alarm panel with gasoline and lead totalizers, control switches, and alarm lights.

monitor the operation of the blender that it will be impossible for any form of improper operation to exist without the operator's attention being called to it.

There are five general alarm circuits and the first notice of any unusual condition is in the form of lighted bull's-eye lights that indicate the circuit affected. A bell signal is connected beyond these lights through a time relay so that unless any condition of unbalance promptly corrects itself, as will most frequently be the case, or unless the operator takes the indicated steps to correct the condition within a pre-set period, usually 5 minutes, the bell signal will sound and continue to ring until the condition is corrected.

The high-low beam alarm has two warning lights to indicate the exact direction of beam deviation. These lights are actuated from mercoid switches mounted in the scale cabinet directly below the free end of the beam. The allowable fluctuation of the scale beam is adjusted by means of the arms actuating the switches.

If the beam varies either up or down beyond the set limit, the appropriate warning light will come on and the time delay in the warning bell relay will be initiated. If the scale beam deviation is in the course of normal operation, as for instance in the case of a sharp change in gasoline flow, the beam will correct its position before expiration of the time delay cycle; the warning light will go out, the bell relay returning to its starting position without sounding the alarm bell.

The vacuum alarm circuit has a bull's-eye light that, however, is not connected to the warning bell. A seal and vacuum-operated switch are connected into the Ethyl fluid line at the top of the vertical riser above the eductor. This vacuum switch serves a dual purpose. At any point of vacuum below a satisfactory operating point, it causes the warning light to light. Its second function is to energize the solenoid-operated check valve in the Ethyl fluid line. At any point of vacuum below 6 in. of mercury, this check valve is closed, but for the duration of any period in which there exists a vacuum of more than 6 in. of mercury, the check valve is held constantly open. This provides against back-flooding of the Ethyl fluid weigh tank, as this solenoid-operated valve will be closed as a falling vacuum passes below the 6 in. of mercury and before any condition of positive pressure has been reached.

Lack of vacuum will result in operation of the high-beam, low-beam alarm circuit as such lack of vacuum will cause the scale beam to become relatively light, placing this circuit into operation, lighting and high-beam light, and causing the alarm bell to sound. Thus there will be two warning lights showing on the panel, indicating the cause of the warning.

There is a mercoid switch connected with the operating air pressure line to actuate a bull's-eye light whenever the control air pressure falls below a minimum set point. Any failure in air pressure will result in a high beam, causing that light to go on and sounding the warning bell.

The Chronoflo system of measurement and control consists of a fixed time cycle; in this case 15 sec., which is divided into an "on" or closed circuit period, the length of which is always exactly proportional to the flow being measured, and a complimentary "off" or open circuit period making up the balance of the 15-sec. cycle. The cam, revolving at constant rate, in the transmitter is driven by a telechron motor and, if this motor should fail, the period in the cycle present would be continued indefinitely. Thus, there might be a condition of continuous "on," or closed circuit, in which case an over-demand of lead would be set up; or there might be a continuous "off" period that would result in no lead demand. Neither case would be reflected in a change of beam position because, in the former, the regular control mechanism would allow sufficient lead to be withdrawn from the Ethyl fluid tank to correspond with the demand as registered by the transmitter. In the latter condition, the lead control valve would be shut down before the scale beam could get definitely low.

To guard against these conditions resulting from possible motor failure, two dashpot time relays are respectively connected across the opposite sides of the Chronoflo signal relay. Each of the time relays is set for a time in excess of the 15-sec. cycle so that neither relay will close unless a condition of either "off" or "on" signal persists for more than one full cycle. The contact closure of either dashpot relay will initiate the time delay in the bell relay, resulting in the audible alarm.

A three-way solenoid-operated pilot valve is inserted in the incoming air line as an air supply safety control. The coil of this solenoid is energized from the motor starter of the small eductor pump. If, for any reason, the eductor pump is shut down or cuts out, this solenoid will be de-energized changing the position of the ports in the valve and, by venting to atmosphere all available control air will immediately cause the Ethyl fluid control valve to close, cutting off all flow of Ethyl fluid. This, in turn, will unbalance the scale, light the bull's-eye, and cause the alarm bell to sound.

The blender is so designed that in case of any emergency, the unit may be operated as a batch-type blender.

▸ **Results.** The following test run data are indicative of the uniformity of the blend obtained by the installation at Toledo. A run, in which the objective was to add 1.2 cc. of tetraethyl lead per gal., was started at 8:10 a. m. and continued until 8:45 p. m. By totalizer reading, the amount of Ethyl fluid added showed as 5553 lb.; by the difference in scale beam reading, the fluid added showed as 5549 lb. During the run, 8 blended gasoline samples were withdrawn from the field storage tanks. The average of the samples showed 1.22 cc. of tetraethyl lead per gal.

▸ **Acknowledgments.** The writer is indebted to J. F. Hearn, Sun Oil Company, and O. B. Lewis and B. G. Crane, Ethyl Corporation, for valued assistance in supplying data for this manuscript. He is also indebted to R. P. Lowe, % Proportioners, Inc. % for a copy of, and permission to quote from, "Instructions for Installation, Operation and Maintenance of Continuous Automatic Loss-in-Weight Ethyl Blender." ★ ★ ★

Evidence shows high accuracy for preliminary data

Remarkable agreement is found in the first comparison of *The Petroleum Engineer's* monthly data on the national oil situation with official figures from U. S. Bureau of Mines. Reports are published by the magazine six weeks before the Bureau of Mines releases its statistics. For those who must keep abreast of oil trends the advantages of obtaining such advance information are obvious.

A comparative table below indicates the similarity in *The Petroleum Engineer* preliminary figures and the Bureau of Mines reports:

COMPARATIVE DATA ON NATIONAL PETROLEUM SITUATION

	REPORTS FOR AUGUST		CUMULATIVE	
	The Petroleum Engineer for Sept. 15	*U.S. Bureau of Mines for Oct. 30*	*The Petroleum Engineer*	*U.S. Bureau of Mines*
Wells drilling	4,210	4,132	.....	.....
Wells drilled	2,086	2,055	14,022	14,212
Crude production* (daily)	4,681	4,687	4,523	4,509
Crude stocks*	230,015	230,192	.....	.....
Natural gasoline production* (daily)	281	283	270	272
Motor fuel production*	2,035	2,067	1,973	1,982
Gasoline yield, per cent	38.4	39.4	38.8	38.9
Motor fuel stock*	73,375	70,753	.....	.....
Fuel oil stock*	94,620	94,218	.....	.....
Refinery runs (daily)*	4,685	4,614	4,501	4,500
All refined stocks*	250,300	245,390	.....	.....

*Thousands of bbl.

DAILY CRUDE PRODUCTION

	The Petroleum Engineer	*U.S. Bureau of Mines*		*The Petroleum Engineer*	*U.S. Bureau of Mines*
Texas	2,130	2,130	Arkansas	82	82
California	862	859	New Mexico	106	105
Oklahoma	341	338	Mississippi	45	45
Kansas	277	272	Illinois	206	211
Louisiana	359	355			

31 G-MV Compressors

(PRODUCING 31,000 HORSEPOWER)

on the Tennessee Gas Line

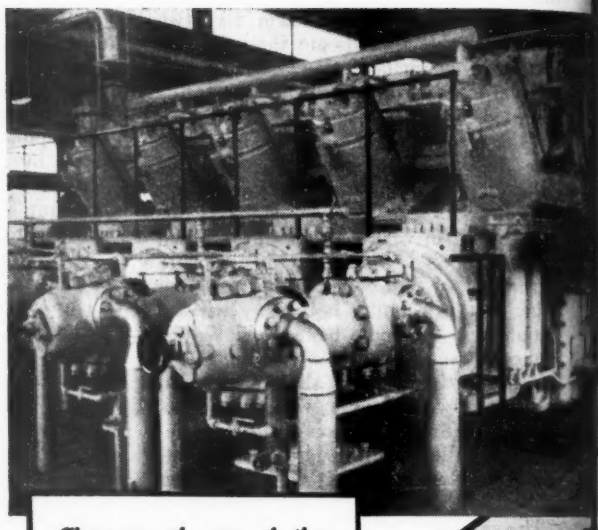
The G-MV's are in operation — pumping gas on the new Tennessee Line from Corpus Christi to Cornwall — 31 big 10-cylinder V-angle engines, each developing a conservative 1,000 horsepower.

These Cooper-Bessemers, representing well over half the compressor horsepower on the Tennessee Gas & Transmission Company project, are located on the northern portion of the line — at the Batesville, Miss., Lobelville, Tenn., Campbellsville, Ky., and Ashland, Ky., stations.

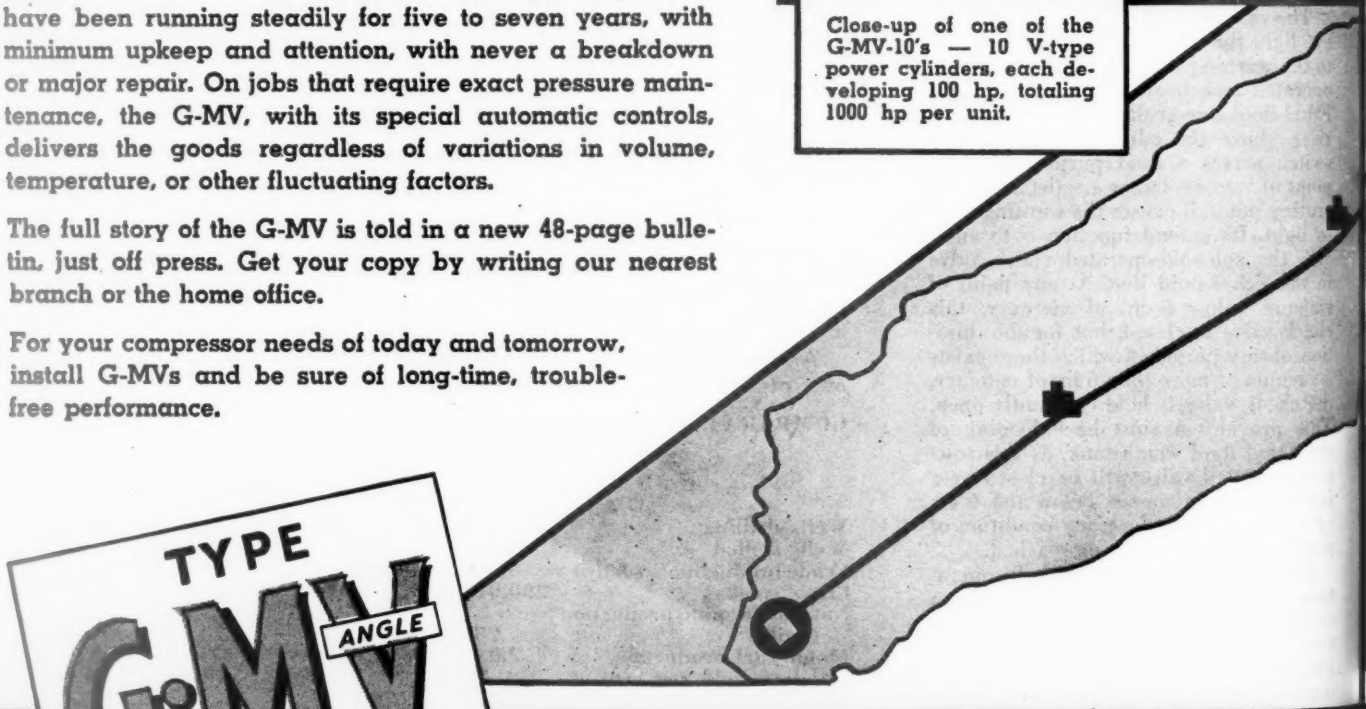
In selecting the G-MV, T. G. & T. officials picked the most efficient compressor to be had — one that has stood the test of continuous, tough performance — not only in gas transmission, but in all other phases and types of compressor service as well. Scores of units operating today have been running steadily for five to seven years, with minimum upkeep and attention, with never a breakdown or major repair. On jobs that require exact pressure maintenance, the G-MV, with its special automatic controls, delivers the goods regardless of variations in volume, temperature, or other fluctuating factors.

The full story of the G-MV is told in a new 48-page bulletin, just off press. Get your copy by writing our nearest branch or the home office.

For your compressor needs of today and tomorrow, install G-MVs and be sure of long-time, trouble-free performance.



Close-up of one of the G-MV-10's — 10 V-type power cylinders, each developing 100 hp, totaling 1000 hp per unit.



TYPE G-MV ANGLE Compressors

New York Washington Bradford, Pa. Parkersburg, W. Va. San Francisco, Cal. Seattle, Wash.

Compressor station at Lobelville, Tennessee, housing eight Cooper-Bessemer Type G-MV Compressors.

Cooper - Bessemer G - MVs equip 4 of the compressor stations now installed. Seven more to be built later.

Interior of the compressor station at Lobelville, Tenn., showing the battery of eight big G-MV's, representing a total of 8000 horsepower.

s by Cooper-Bessemer

DEEP WELL PUMPING

By **WALLACE A. SAWDON,** *Pacific Coast Editor*

EXCLUSIVE With wells going deeper and deeper and production from below 10,000 ft. being no longer unusual, it is natural that increased attention should be given to deep well pumping. Methods of prolonging the period of production by natural flow and gas lift are most important in deep producing areas but the oil must eventually be lifted by other means.

The deep fields of California have offered opportunities to test deep pumping methods and fluid is now being lifted by artifical means from depths greater than 10,000 ft. This is in addition to gas-lift installations, which, strictly speaking, employ artificial means of lifting the fluid. Gas-lift operations include the simple gas injection methods and the use of valves and other equipment run into the well to provide intermittent flow or to procure other results, but pumping is here considered as confined to the use of oil well pumps actuated by sucker rods, of hydraulic pumps, and of plunger-lift. The deepest installations of these pumping methods here cited show the depths at which they are operating satisfactorily at the present time and indicate the possibilities for deeper pumping.

California oil is being lifted by artificial means from depths exceeding 10,000 ft., affording opportunity to test deep pumping methods.

In planning the type of pumping equipment to use, the volume and weight of fluid to be raised must, of course, be considered in connection with the depth. Other factors such as gravity of the oil and the amount of water being produced, the viscosity of the fluid, paraffin content, sand conditions, volume of gas, and other conditions peculiar to the well are also given consideration.

When pumping with rods, not only the efficiency of the pump itself but also the stress on the rods and the matter of rod replacement costs have to be taken into account. A single well is sometimes an individual problem but in many of the fields such as Santa Fe Springs where comparatively deep pumping has been practiced for years, groups of wells pumping from approximately the same depths with similar type production can be operated similarly. Data accumulated during the pumping of the Santa Fe Springs wells from 7000 to 8000 ft. have been of great value in planning equipment for depths greater than 8000 ft. although the deepest wells on the pump in that field at the present time are a few feet less than 8000.

Surface units for rod pumping are now designed in sizes that can probably handle any load imposed by the rods. The long stroke is being used effectively and counterbalancing has provided a high degree of efficiency. The design of the pumping unit is an important factor and a proper installation will influence volumetric efficiency of a pump handling gassy fluid as well as decrease the peak loading and sucker rod failure. Some of the largest beam-type pumping units yet built are in service in California. One such unit is pumping a well drilled to 9200 ft. and, although the pump at present is set at 7800 ft., and is thus not the deepest rod-pumping installation in the state, it is expected to pump from a much greater depth, possibly below 9000 ft. as the fluid level lowers.

The deepest rod-pumping in California (but not the deepest pumping) at the present time is in the Rosecrans field near Los Angeles. Total depth of this well is 8708 ft. and the pump is set at 8625 ft., which is probably the greatest depth of rod pumping in the world. The tubing is 2½-in. EU and the pump is 1½ in. The rod string consists of 4545 ft. of ¾-in. and 4080 ft. of 7/9-in. rods. The fluid is being pumped with a 120-in. stroke at from 5 to 5½ strokes per minute. Production is 86 bbl. per day gross, 52 bbl. per day net. The installation has been in service for about one year and to date no rods have parted.

THE deepest pumping well in the state (and probably in the world) is 10,034 ft. This well is being pumped by a hydraulic pump and is producing approximate-

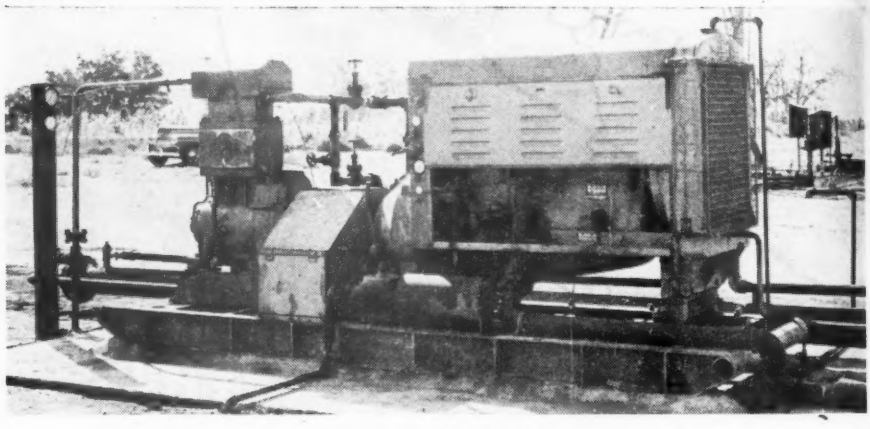


Photo courtesy of Kobe, Incorporated.

Deepest pumping well, showing wellhead in the right background and power oil pumping equipment in foreground. The pump is set at 10,034 ft.

Pumping unit with 10-ft. stroke, 750,000 in-lb. gear torque. Installed on 9000-ft. well where pump is set at 7800 ft.

Photo courtesy of Lufkin Foundry and Machine Company.

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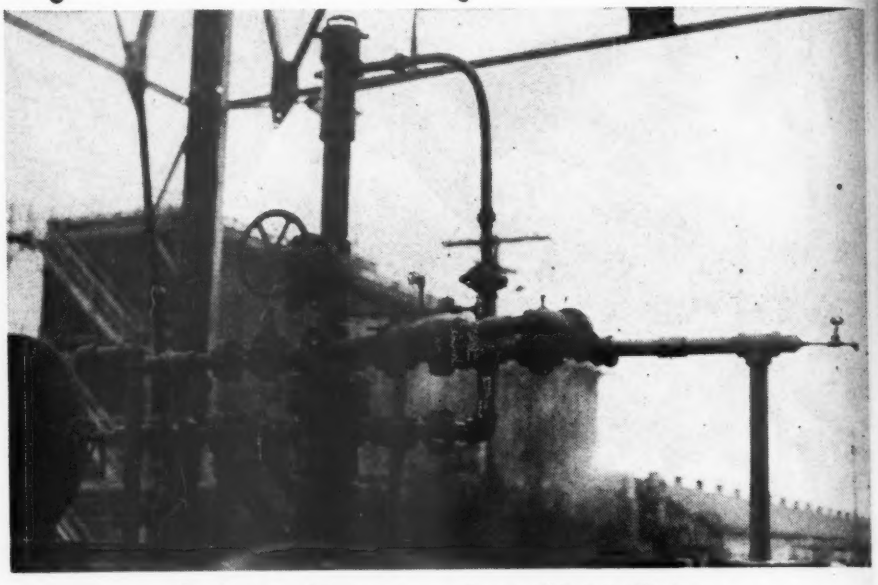
The hydraulic pumping equipment on this well is the widely known type and consists essentially of two parts: The subsurface, or production, unit and the surface, or hydraulic-power, unit. The subsurface unit is a pump-and-engine assembly that is usually run into the tubing as an insert pump on a macaroni string called the power tubing, the assembly seating in the shoe of the production tubing in the conventional manner. The engine actuating the pump is driven by clean oil forced down the power tubing. This power fluid, after actuating the engine, is discharged to mix with the well production and is carried up to the surface with it through the annulus between the power tubing and the production tubing.

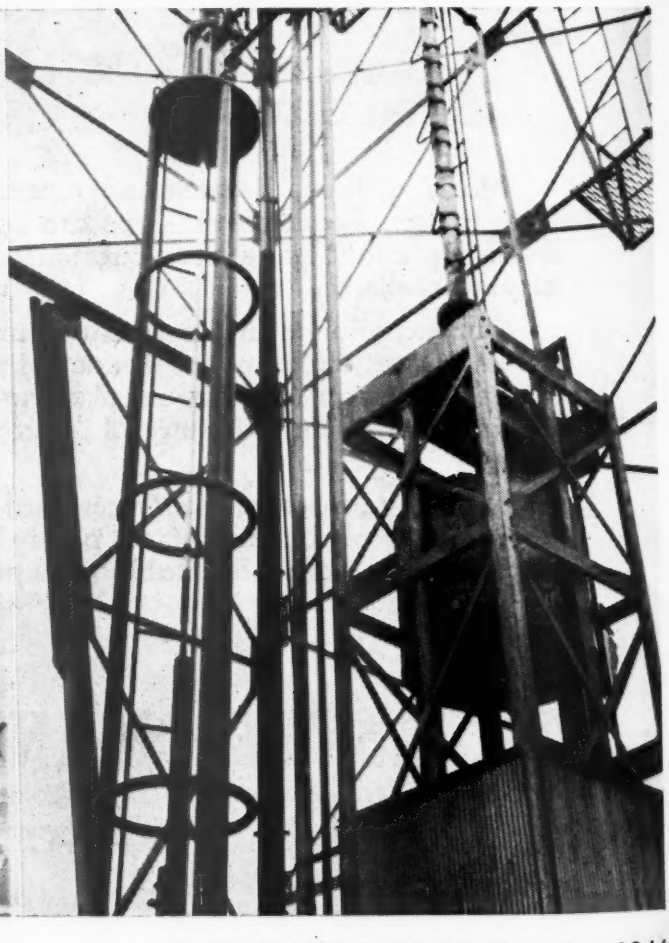
The hydraulic-power unit at the surface supplies the pressured oil that operates the pump engine in the well. This unit consists essentially of a triplex pump and its engine or motor, together with other equipment necessary for preparing and controlling the power oil and its flow to meet the existing conditions.

A FEATURE of hydraulic pumping is that the surface pumps for a number of wells may be grouped at a central station with manifolding of the individual well system, which provides control of the power oil to each well to procure maximum pumping efficiency, even under changing well conditions. Pump units may be added to or taken away when desired. The triplex pumps are assembled with conventional gas engines or provided with integral electric drive or separate belt drive.

The deepest California wells being produced by plunger-lift installations range from 8000 to 8500 ft., there being several within that range at the present time. The lifting force in this type of installation is provided by gas, but because the oil is actually raised to the surface by a plunger, it is here included as a pumping method. This plunger travels the entire distance from the bottom to the top of the tubing and back again at each stroke but it does not lift a column of fluid extending the full length of the tubing. The plunger acts more or less as a swab without a line and produces the fluid in short heads that are usually less than 300 ft. in length. It brings up at each stroke all that comes into the hole during the time it is making the trip, this including oil,



Surface equipment on a plunger-lift installation.



***Left*—Deepest rod-pumping well, pump being set at 8625 ft. The surface unit is of the hydraulic type. *Right*—Part of pumping unit on same well.**

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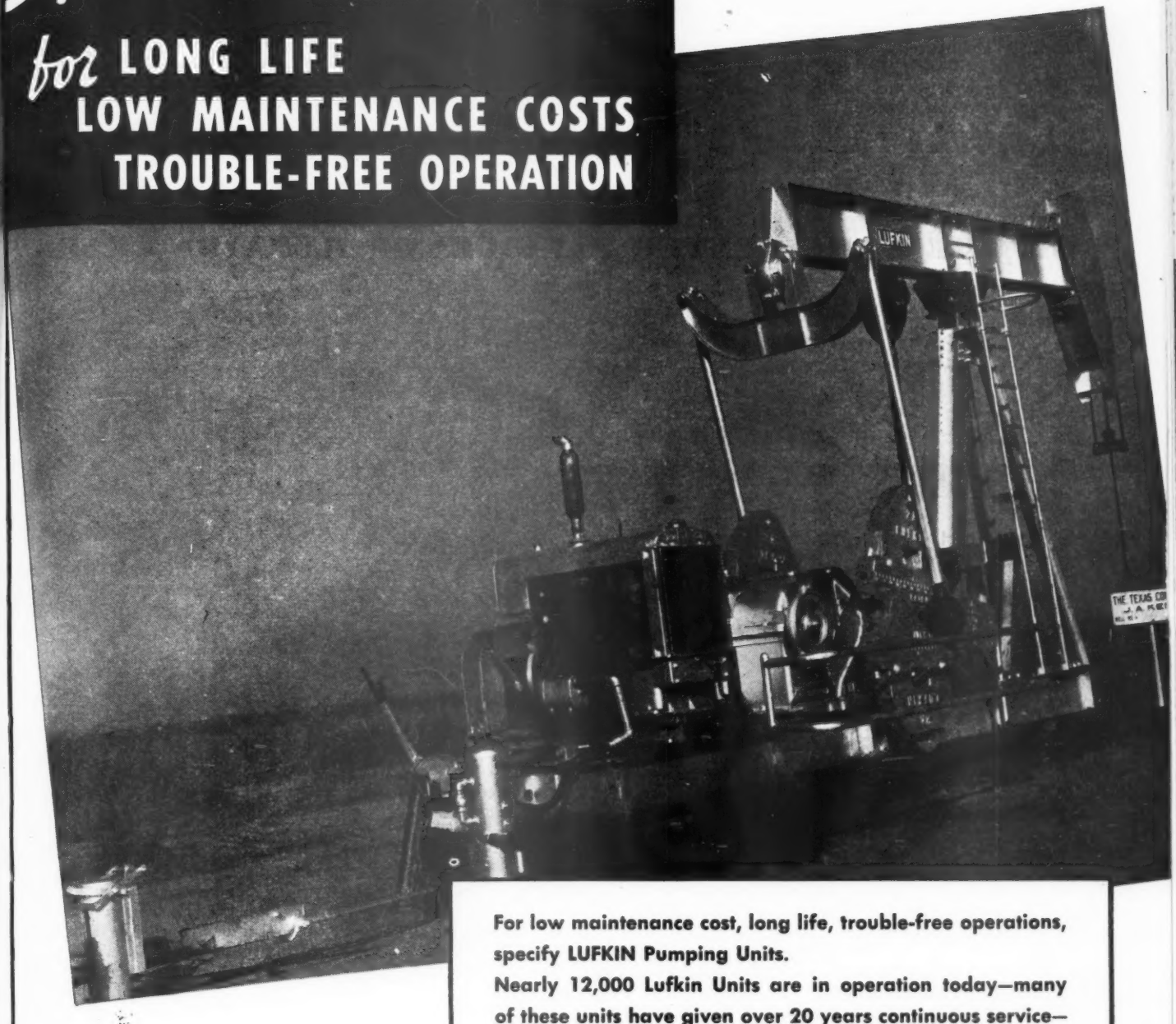

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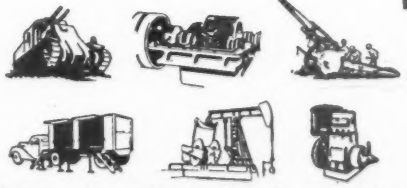
Nearly 12,000 Lufkin Units are in operation today—many of these units have given over 20 years continuous service—and our repair sales to all oil companies are negligible—a record we are proud of.

Lufkin Units are made in capacities to take care of all conditions—long or short stroke, and for the deepest wells. Consult the nearest Lufkin sales office today. Plan a long-range program now and be assured of superior Lufkin equipment.



In addition to the production of tank gears, ship gears, gun carriages and truck trailers for our armed forces we are also producing in ever increasing numbers, LUFKIN PUMPING UNITS and COOPER-BESSEMER ENGINES for America's vital oil industry.

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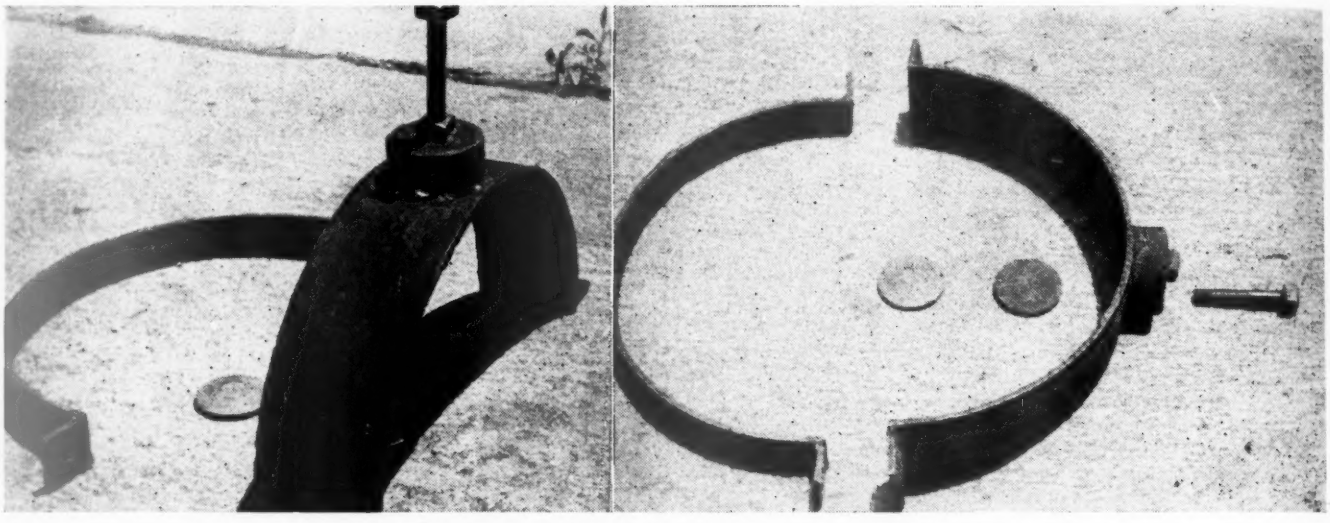
water, gas, froth, and sand. In some cases the plunger-lift has handled as much as 10 per cent of sand.

The plunger operates in tubing that is drifted as it is run into the well and that is supported from a flow head at the surface. This head is adapted to receive the slug of oil lifted by the plunger and direct it to the flow lines. A foot-piece at the bottom of the tubing stops the plunger and closes a valve in the plunger at the end of the down stroke. The valve and cage of the plunger are so designed that neither gas nor liquid will close the valve; it must be closed by the valve stem landing on the foot-piece. The valve is opened at the top of the up stroke to permit the plunger to return to bottom by gravity. The operating pressure per bbl. of production for any given size lift goes up as the depth increases. With the 3-in. size, for example, this increase is approximately 0.1 per bbl. per 1000 ft.

Rodless pumping as now developed should be able to lift fluid from any depth yet drilled. As more wells producing from below 10,000 ft. go on the pump, further experience will be gained and it can be expected that greater efficiency and economy will result. The fears of not so many years ago that pumping costs of these very deep wells would be so high that their production by pumping might not be warranted now appear groundless. ★ ★ ★

P 625.4

HIGH PRESSURE VENTED PLUG CLAMP REPAIRS LEAKS



Two views of high pressure vented plug clamp used to repair leaks in gas pipe lines.

J. J. WATSON, crew foreman at Tyler, Texas, for United Gas Pipe Line Company, has developed what is termed a high pressure vented plug clamp used to repair leaks in gas pipe lines.

The clamp developed from an effort by Watson to perfect a clamp that would combine features of safety and effective and lasting repair. In developing the clamp he adopted simplicity of design and at the same time attempted to incorporate all basic principles required in a satisfactory repair unit. The aim was to design a clamp that would repair a leak effectively; effect, as nearly as possible, a permanent repair; minimize the possibility of burning out gaskets; strengthen pipe instead of weakening it by the tremendous band pressure required to seal off a leak with an open band, and put pressure on the rubber gasket so that the band would serve only as an anchor to hold the gasket in place.

The first clamp was a 4-in. model, tested on a 4-in. header built especially for the test. An acetylene weld was run, extending ¼ in. from the surface of the pipe, and slits 1 in. in length were cut across the weld and into the pipe. Against 275-lb. pressure the model clamp stopped the leak quickly and satisfactorily.

The accompanying photographs illustrate the simplicity of the clamp and its component parts. It consists of 2 half bands of different widths, the wider half being the part to which is attached the leak-stopping arrangement. A hole is cut in the wide half of the clamp, and a short nipple is welded on to encircle this hole.

A flat plate covering the outside of the nipple is punched and a nut welded on to receive a set screw. Other parts include a steel disk and the rubber leak plug to be inserted in the receptacle formed by the short nipple and the bolts for securing the two halves of the clamp in a complete band around the pipe.

In repairing a leak with the Watson clamp, the steel disk is inserted first, followed by the rubber plug. The set screw is then screwed into the nut until it comes in contact with the steel disk. The halves of the clamp are then bolted together around the pipe just tight enough to permit sliding the clamp over the leak.

With clamp in position over the leak, the set screw is tightened down forcing the rubber leak plug, prevented from spreading by the encircling nipple, into the leak and stopping the escape of gas. Side bolts may then be drawn tight to secure the whole assembly in permanent position.

A small hole cut in the wall of the plug cavity allows gas to escape while the set screw is being tightened, preventing a build up of pressure to hamper the operation or threaten the safety of workmen. Another practical feature of the clamp is its compactness. The nipple and screw attachment are short enough that the entire assembly may be covered by a split sleeve should the necessity arise.

The clamp has been successfully used in the Dallas district where it has been found adaptable to any pipe diameter. ★ ★ ★

Form association

Lewis R. Keith, Russell, Kansas; A. J. Hoover and Frank M. Mahan, both of Tulsa, Oklahoma, are chairman, vice chairman and secretary, respectively, of the Mid-Continent Rig Building Association, newest oil country trade organization, formed recently at meetings in Tulsa and Dallas, Texas. A later conference of the National War Labor Board and the rig builders covered: Time and a half for more than 40 hr. a week when employees worked for several contractors during the period, room rent of workers, payment of travel time for skidding work, etc.

FUNDAMENTALS IN AUTOMATIC CONTROL

By **DONALD P. ECKMAN,** The Brown Instrument Company

BOTH wartime production and, by all indications postwar production, too, calls for immediate full and more complete understanding and appreciation of the fundamentals of automatic control. Peace may assure industry more time for study, examination, and experiment. Yet, it will be found that what is known now about automatic control fundamentals, and the more they are understood and appreciated, the speedier will be the conversion to postwar requirements.

Instruments, particularly controllers, have become increasingly the means of meeting wartime demands for greater output, higher quality, and increased operational efficiency. With a promise of an increase in both domestic and foreign commodity competition after the war, plus an even greater competitive wage situation due to world conditions, all three factors — quality, efficiency, and speed—will be the basis for American industrial success. That success, can be attained in great part through a realization now that automatic control and its fundamentals are important.

Proportional control is a mode of control that positions the control valve in accordance with magnitude of the controlled variable. This control function is largely stabilizing and, if not too great, forces the controlled variable to line out at some point. It will not prevent permanent deviation from the control point upon a change in load.

Reset response provides an additional increment of valve position in proportion to the deviation and the time of deviation of the controlled variable from the control point. This control function has very little stabilizing effect but, if not too great, tends to prevent deviation from the control point for changes in load.

From these definitions it is obvious that the control system and the process must be considered together as a dynamic unit, for a change in one part carries through so as to affect the whole system. Thus, automatic control must always be measured in terms of moving or dynamic conditions, not steady or static conditions. One proof of this is shown by the fact that a deviation must be detected before the controller can act. Therefore, a deviation, no matter how small, must occur.

In nearly all cases discussed here the controlled variable will be temperature. The discussion applies in general, however, to the control of pressure, flow, and liquid level when allowances are made for the greatly different process characteristics.

Action of control responses. Disregarding the process for the moment, we wish to study the pen and valve movements when proportional and reset responses are used in the control system. Fig. 1, Curve A, shows a deviation chosen as an example. The control valve is bypassed so that no control action results from its movement.

In the definition of proportional action, valve position was found to be proportional to the deviation. Curve B shows the valve movement that would result from this deviation when a proportional controller is used. Note that this curve is similar to the deviation curve. A proportional controller always has the characteristic that a certain pen position is accompanied by a certain valve position. Stated in other words, the rate of valve movement is always proportional to the rate of pen movement.

Instruments have been an important means of meeting wartime demand for greater output, higher quality, and increased operating efficiency.

In actual practice this recovery action would result from a very temporary change in load, the load returning to exactly its previous value.

In the definition of reset response, the valve position was found to be proportional to deviation and time of deviation. Suppose that, at the time interval marked "dt" on the time axis of Curve A, the deviation in temperature is D, as shown. The definition of reset shows that during time dt the valve will move an amount proportional to D times dt.

Starting at the beginning of the deviation and moving the valve at each dt an amount proportional to $D \times dt$, the value will move as in Curve C. What really has happened, is that Curve C represents the area under the deviation curve and the reset has integrated or added the sum of the small $D \times dt$ areas.

But since reset response is generally used in conjunction with a proportional controller, these two effects must be added together. Curves B and C are added and shown in Curve D.

In actual practice, this recovery curve would occur on a permanent change in load, reset response having closed the valve an additional amount to maintain the temperature at the control point.

It is easy to show how controller actions bear a definite relationship to the deviation. These actions may be combined into an equation and it is surprising to discover how well automatic controllers follow a definite relationship.

First, in reset action, valve position is proportional to the area under the deviation curve. As before, this area was obtained by adding all the deviations multiplied by the time at the deviation. In proportional action, valve position is proportional to the deviation.

Combine these actions and show the valve position at any time as an equation:

$$V = K_1 \int_{t_i}^{t_a} D\,dt + K_2 D \quad \ldots \quad (1)$$

(reset) (proportional)

V = valve position
K_1 = the reset rate-adjustable constant
D = the deviation of variable from control point
K_2 = the proportional band-adjustable constant
t = time

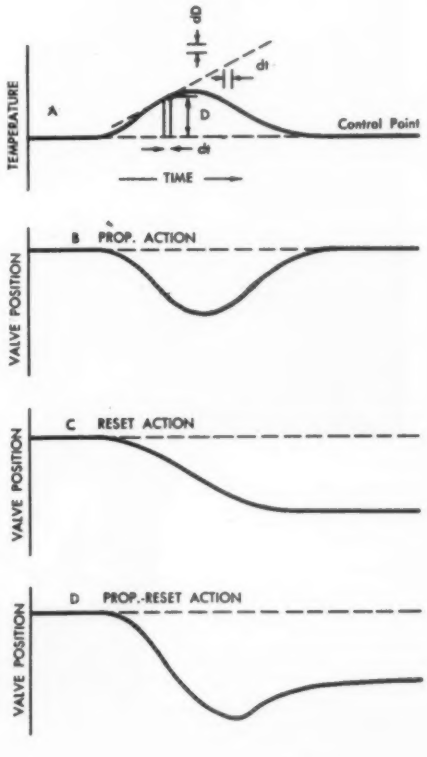
If a controller does not have all these responses the appropriate term is zero. Thus, a proportional controller would be

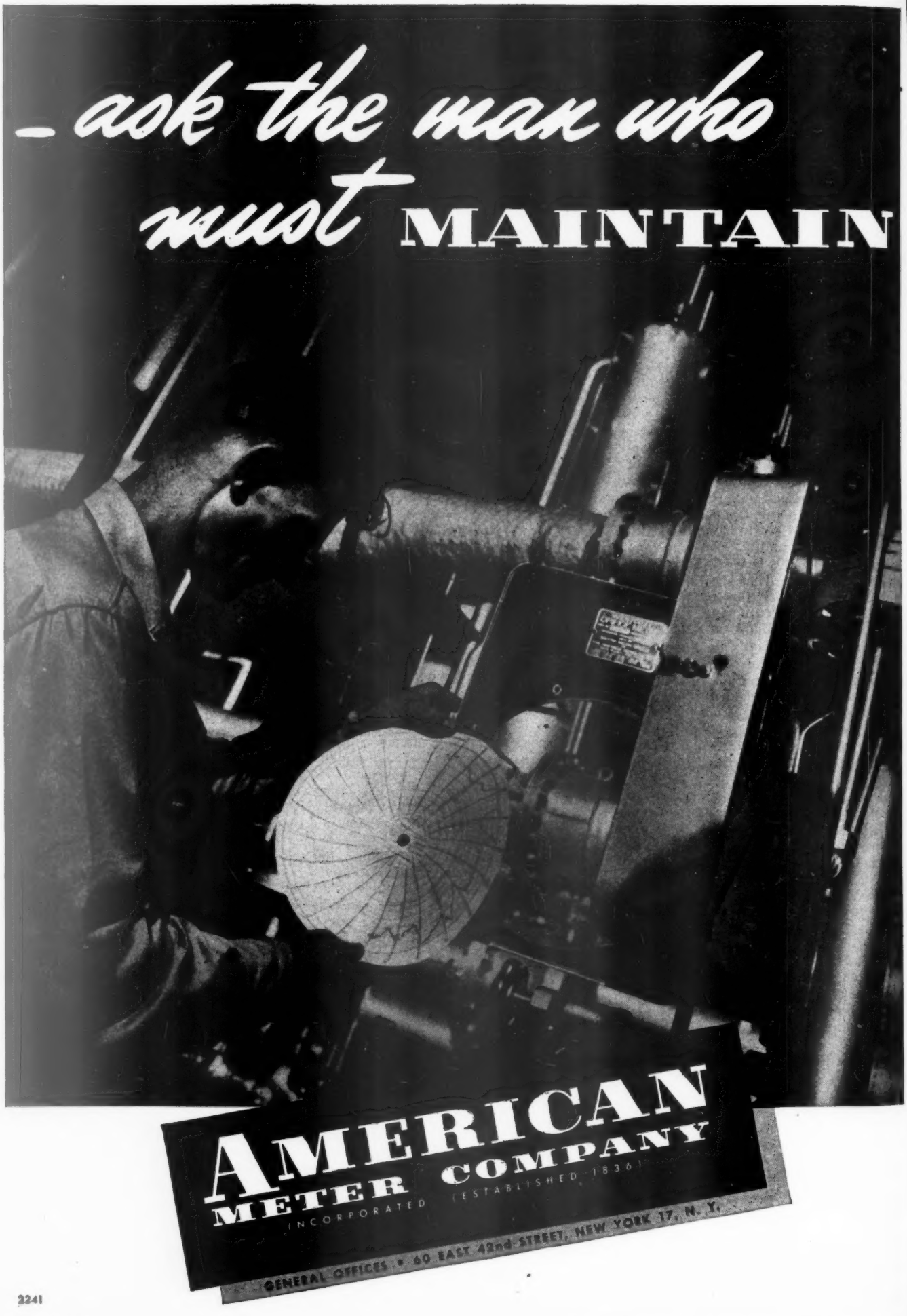
$$V = K_2 D \quad \ldots \quad (2)$$

Equation (1) is of the type which is

(Continued on Page 80)

FIG. 1

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Adjustments are made easily without interfering with any of the working parts...and using only ordinary tools.

With fewer operating parts there's less to wear. Less to get out of adjustment. It's a more dependable mechanical meter from the standpoint of *sustained* accuracy...

These are some of the advantages which distinguish AMERICAN orifice instruments in operation.

That is why, also, such reliance is placed upon AMERICAN instruments for service in remote parts of the globe, where skilled maintenance is difficult.

And in AMERICAN *Ironcase meters too...* the same emphasis has been placed upon design and construction to lessen wear of operating parts.

Consider what these features mean in terms of return on your investment, accurate uninterrupted meter service, and reduced upkeep cost...Full bellows diaphragms...Provision for correct lubrication of bearings... The one-piece body with table, partition, outlet channel and diaphragm channel, all cast as one unit. (The avoidance of gaskets between parts makes internal leakage impossible.)

In every detail of construction, including the development of special bearing metals, the Ironcase meter gives you the benefit of cumulative experience in measurement engineering.

Ironcase meters are available in a complete range of sizes and pressures.

Shown above is the AMERICAN *500-B Ironcase equipped with our Base Pressure Index. The latter gives a totalized reading of the quantity of gas which passes through the meter in cubic feet (at the base pressure). Each cubic foot (at line pressure) is multiplied automatically by the factor for line pressure.*

It is equipped with a supplementary counter in the rear which gives a reading of the actual volume at line pressure. This is required when this index is used with a Volume and Pressure Gage, which gives a permanent chart record of rate of flow and pressure.

(Continued from Page 77)

known mathematically as the first few terms of an infinite series. Thus it might be possible to add to the controller response many of the higher derivatives as below:

$$V\ K_1 \int_{t_i}^{t_n} D\,dt + K_2 D + \frac{K_3 d D}{dt} + \frac{K_4 d\ D}{dt} + \ldots\ldots\ldots + \frac{K_n d\ D}{dt}$$

A controller built to include many higher derivatives, even if electronic in nature, would be far too complicated and expensive. From a practical standpoint, proportional response alone is sufficient to handle significantly large numbers of processes.

Process characteristics affecting control. All processes are more or less complicated arrangements of a number of capacities, transfer lags, and dead times. The extent of these factors determine the complexity of the control problem.

Capacity produces a retardation, not a delay, by the ability of sections of the process to absorb energy without causing an immediate full rise in potential. Compare this with an electric capacitor which can absorb electrical current and thus delay the rise of voltage until it is charged. The ability of the brick walls in a furnace to absorb heat, the volume of liquid in a tank which affects the liquid level, and the amount of steam required to raise the pressure in a steam cooker, represent capacity.

Transfer lag is a retardation, not a delay, caused by the potential drop between two separated capacities or over distributed capacity in the process. This can be compared to an electrical resistor between two electrical capacitors. The temperature drop across a boiler tube or a heat-exchanger tube, the pressure drop across a valve connecting two tanks, or the temperature drop across an insulating wall represent resistance of the kind that causes transfer lag.

Dead time is a pure time delay that arises from the necessity of transporting a mass of liquid, gas, or solid from one point to another. The distance between a heat exchanger outlet and the thermocouple, and distance between an oil burner and the material being heated, and the distance between a control valve and the fuel burner, all represent a small but sometimes appreciable dead time during which no change can be effected.

Not only the process itself, but the measuring and control systems have capacity, transfer lag, and dead time. Fig. 2 shows a typical process with all the various sections which make up the system. All processes or controllers do not have this arrangement, some having fewer and some having more component parts.

Consider what actual characteristics enter into each of the blocks in a diagram. Assume that the process is a fuel-fired waterheater and that we wish to know what each of the blocks in the diagram represents.

Input dead time is the time required for fuel oil to flow from control valve to burners.

Supply capacity is the heat storage capacity of the firebox.

Supply dead time is the time required for hot gases or flame to travel from firebox to water tubes.

Transfer resistance is the resistance to heat flow across the water tube from gases to water.

Demand dead time is the time required for water to flow from water tube to header.

Demand capacity is the heat storage capacity of water in tubes and header.

Output dead time is the time required for heated water to flow from the tubes or header to the point where the thermo-

FIG. 2

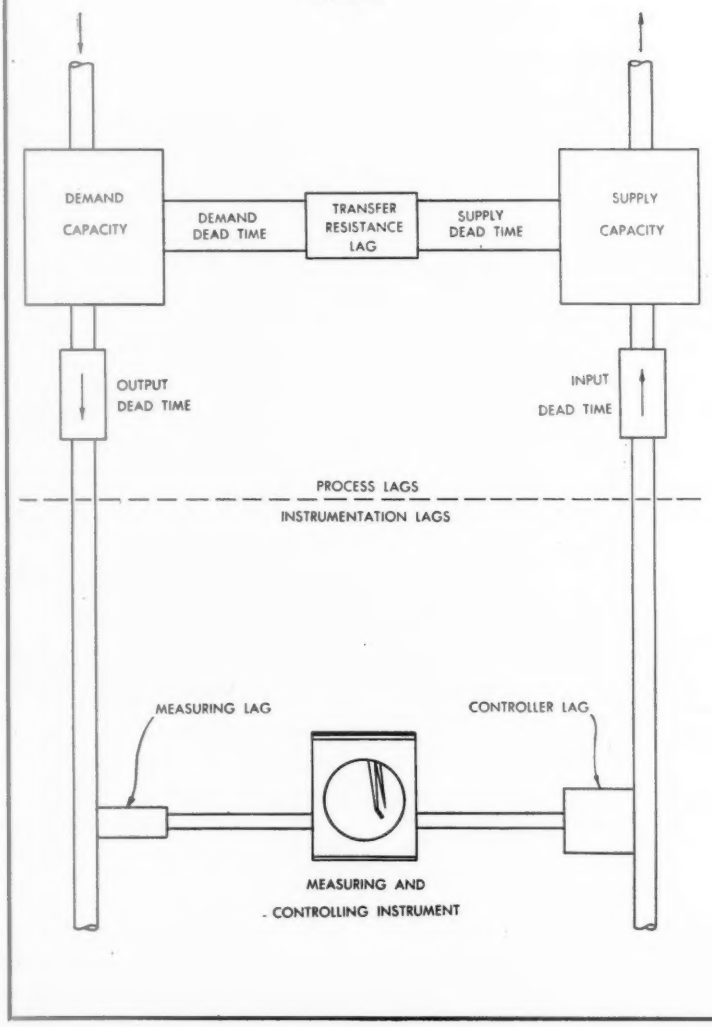


FIG. 3

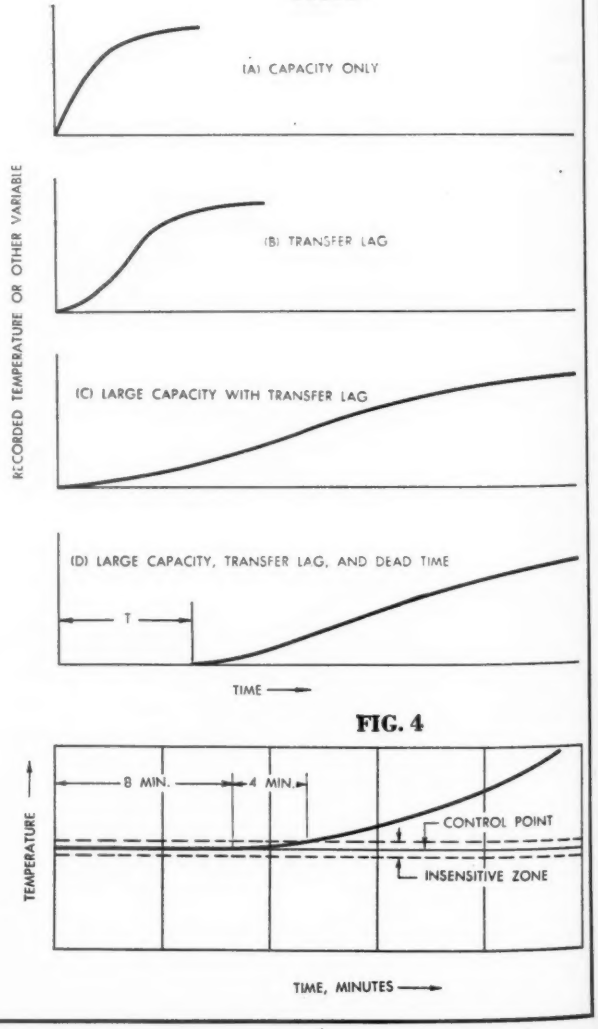
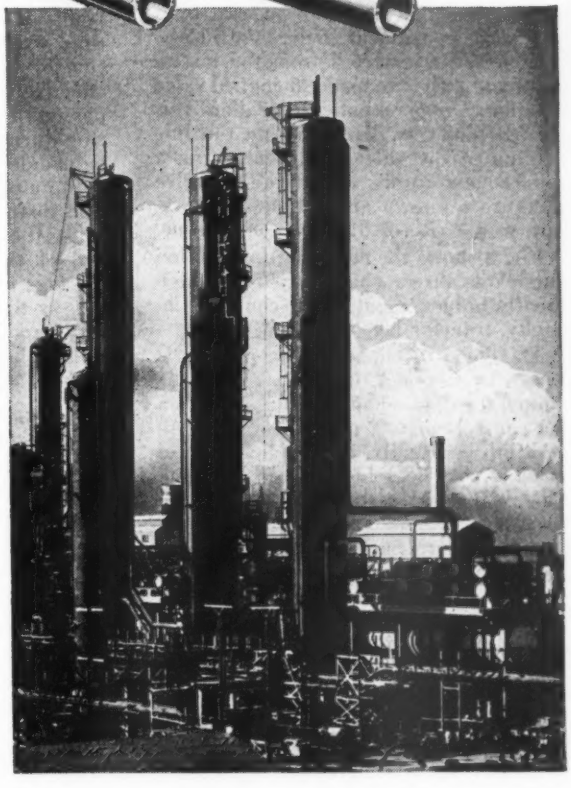


FIG. 4

for HIGH TUBING ECONOMIES in HIGH TEMPERATURE, HIGH PRESSURE service

Many refineries, synthetic rubber plants, and chemical plants are taking advantage of B&W low and intermediate alloy steel seamless tubing for applications requiring resistance to high temperatures, high pressures, and corrosion. The key to successful application of this tubing is in the choice of the correct alloys for given conditions. For example, B&W Croloy tubes are today serving satisfactorily and economically in the production of 100-octane aviation gasoline and in many other applications for which higher alloys were previously thought necessary.

In matching tubing to present-day refining and processing conditions, the cooperation of B&W engineers can prove of inestimable value. This service, based on more than thirty-five years of B&W specialization in pioneering, introducing, and producing tubes for high-temperature—high-pressure service, is available to you.



CROLOY 1¼	CROLOY 2	CROLOY 2¼
Economic grade good creep strength properties. Somewhat more corrosion resistant than the chromium free steels.	Economic grade for resisting both oxidation and corrosion, with excellent high-temperature strength.	*Exceptionally high creep strength* for polymerization and high pressure cracking. Otherwise similar in properties and characteristics to Croloy 2.
CROLOY 3 M	**CROLOY 5**	**CROLOY 5 Si**
Somewhat better creep properties and better resistance to corrosion and oxidation than Croloy 2.	For operating conditions where corrosion resistance is primary requirement—provides good creep strength and oxidation resistance superior to Croloy 2.	For operating conditions where oxidation resistance is a primary requirement. Excellent resistance to scaling.
CROLOY 5 Ti	**CROLOY 7**	**CROLOY 9**
For oxidation resistance. Non-hardening below 1700° F.	Intermediate steel between Croloys 5 and 9 for operating conditions where corrosion resistance is the primary requirement. Somewhat more oxidation resistant than Croloy 5.	For severe operating conditions where high corrosion and oxidation resistance are essential—suitable for hydrogenation processes.

TA-1312

couple or the thermometer bulb is located.

Measuring lag is represented by the heat capacity and resistance to heat flow in the thermocouple or thermometer bulb and its protecting well.

Controller lag is represented by the lag of response of the control valve—in electric control by the speed of the motor valve operator, and in pneumatic control by the pressure storage capacity of the valve topwork.

Process reactions. In order to illustrate the effect of capacity, transfer lag, and dead time, the reactions of the furnace or other process to changes in fuel flow may be employed. This method was previously used to illustrate controller action by moving the pen and observing the resultant valve action. To illustrate process characteristics the control valve is moved and the action of furnace temperature observed.

The reaction curve is simply the curve of temperature, (or other variable), versus time that would be drawn by a recording instrument if the control system were disconnected from the instrument and a change made in control valve position. On pneumatic controllers this may be done by disconnecting the line leading to the valve, and connecting a separate air supply. By varying the valve pressure a known amount the temperature would rise or drop to a new value.

Fig. 3 shows the effect on the reaction curve of three characteristics which greatly influence automatic control: Capacity, transfer lag, and dead time.

The effect of capacity in a process is shown by Curve A. Capacity allows the temperature to change instantly when the control valve is moved but the temperature gradually approaches a final value — a typical logarithmic reaction. This type of process reaction is desirable since it provides instantaneous response of temperature but slows down the response sufficiently to prove stability. A reaction such as shown by Curve A is an ideal rarely ever obtained. When a second capacity is associated with the process a transfer lag is generally caused as shown by Curve B. This transfer lag is illustrated by the slow initial response to valve movement which gradually builds up to a maximum rate of reaction. Note that this reaction is greatly different than that one occurring when only a single capacity is involved as in Curve A.

The effect of transfer lag may be caused by an additional retarded response in the process or in the control system. This is a very important consideration in automatic control. The effect of transfer lag arises from:

1. *A supply capacity in a process.*
2. *Distributed capacity in a process.*
3. *A measuring lag.*
4. *A controller lag.*

Since transfer lag is nearly always detrimental to automatic control all four conditions above must be avoided whenever possible.

By using greater process capacity the effect of transfer lag may sometimes be overcome. Curve C illustrates a much greater process capacity than Curves B or A. Transfer lag is indicated by the slow initial rate of change of temperature.

Dead time is the cause of much difficulty in automatic control. When dead time exists, as shown in Curve D, a control valve movement cannot be made effective until the dead time period has passed. Therefore, any deviation occurring during the dead time period cannot be avoided.

In automatic control, it is usually outside disturbances or load changes that cause the major difficulty, and not control of the variable itself. Then, also, the lags of the measuring and controlling systems of the controller form a very important part of an automatic control application, especially when process transfer lag and dead time are small.

Practical aspects of control. There are several factors entering into the control of various processes that produce relatively great improvements in the quality of control. They might be called "fundamentals" but this is only to emphasize their importance.

Any reduction of the dead zone of the measuring system causes improvement in the quality of control, especially for processes having large capacity and transfer lag.

To show how this comes about a reaction curve for a process having capacity, transfer lag, resistance, and dead time, has been redrawn to a larger scale and only the deviation from the control point is shown in Fig. 4.

This is the beginning of deviation from the control point and, from the time that the deviation started at eight minutes until the deviation is several per cent of the controller scale, the control system should begin to function. However, in most measuring systems there is a small zone through which recording is insensitive; that is, the variable (temperature in this case) has changed but the controller fails to detect this change. This dead zone has variously been called "dead spot," "tapping error," and "neutral zone."

Dead zone is usually attributed to the measuring system but may also exist in the control system. Pneumatic controllers are sufficiently sensitive so that as soon as the pen or pointer begins to move, the control system begins to function.

In Fig. 4, the dotted lines above and below the control point represent the width of the dead zone. In this case, the control system does not function until the temperature exceeds the dead zone and it is necessary to wait for 4 min. before corrective action is made. These 4 min. are in addition to the dead time already existing in the process and control system.

Since it has already been indicated that dead time is the cause of one of the most serious difficulties in control, a dead time in the controller further complicates the problem.

An improperly located or poorly installed measuring element results in poor control as well as poor accuracy of measurement.

Much has been said and written concerning the effect of poor thermocouple or thermometer bulb installations on the accuracy of temperature measurement. Its effect on automatic control, however, is not so immediately obvious.

Suppose, for example, that a thermocouple installation as shown in Fig. 5 were encountered. A large loss of heat will occur along the protecting well and heat will be lost to the atmosphere because of the long length of protecting well outside the pipe. This loss decreases the heat available at the thermocouple tip and the temperature reaction at the controller is slow.

A protecting well installed in a horizontal position will allow dirt to settle on the tube if the velocity of the gas will not scour the surface. This increases the thermal capacity because the additional mass must react to temperature changes. The resistance to heat flow from the air to the protecting well is fairly high because the thermocouple tip is located near the outside of the pipe where the velocity is even less than in the center. This increases the measuring lag so that the temperature response is even slower.

The location of the thermocouple downstream from a bend in the pipe causes unnecessary fluctuations of temperature at the thermocouple because of the swirling effect of the gases going around the bend. Usually a thermocouple and protecting well has enough mass to smooth out those fluctuations but comparable difficulties are often encountered in a flowmeter or pressure control installation.

These general principles apply to the installation of almost any primary measuring element. Careful consideration should be given to the losses and to the mass of the detecting element because they very greatly increase the lag of measurement.

Make sure that the control valve is properly installed and is of a type best suited to the job.

In addition to the choice of lift-flow characteristic for a control valve, it is most imperative that it be smoothly operating; that is, have smooth increases

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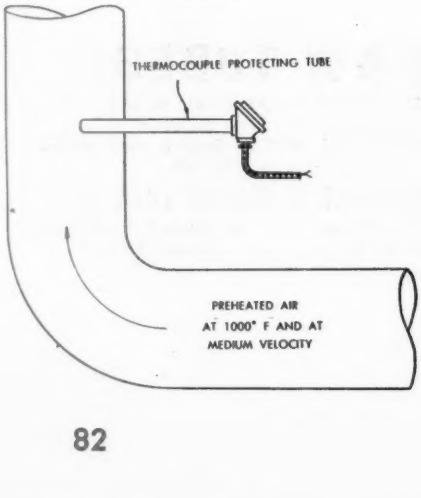
FIG. 5



(Continued from Page 82)

in flow for increases in lift or rotation.

On pneumatic control valves this involves maintaining adequate lubrication of the stem and repacking at frequent intervals when necessary. The average pneumatic control valve, when properly maintained, will operate very satisfactorily but friction at the valve stem which causes sticking can very seriously reduce the number of positions available at the valve. For this reason, there should be no hesitation in using a valve positioner, even if the sticking is only moderate. A valve positioner should always be used, of course, when the proportional band is set to wide values.

Electric motor-operated valves should not be operated with the shaft vertical because thrust causes excessive wear. It is most important that the motor oiling instructions be carefully followed. The resistor and operating contact, as well as the limit switches, for electric control systems should be inspected frequently because dirty or corroded contacts can appreciably reduce the number of steps available.

The ambient temperature at an electrically operated valve should never exceed that specified for that type of electrical equipment. The valve and motor should be installed with the recommended linkage arrangement so that the partial characterization obtained by such means is the most favorable, especially in the case of fuel-air ratio valves.

The influence of outside variables often produces such large upsets that a single controller will fail to maintain process balance. Outside variables should be corrected at the source.

An upset in the supply of the process must carry through the process and finally reach the controller before any correction can be made. The time elapsing between the upset and a complete correction is often very long and serious deviation of temperature may result.

If a controller is applied so as to measure a variable associated with the upset and its effect corrected before it can reach the process, the job of the main controller is greatly reduced and better control will result.

The case in point is the control of temperature of a gas fired furnace. Pressure changes of a very rapid nature often exist in fuel gasolines. When using a controller directly operating a valve these pressure changes cause a change in flow of the fuel which, in turn, upsets the control of temperature. The controller then has a difficult time trying to hold the temperature within limits.

Suppose a flow controller is installed in the gas line and the temperature controller is used to adjust the control point of the flow controller. This arrangement is commonly called metered control. Now, if a pressure change in the gas line occurs, the flow controller detects the change in flow and makes a correction immediately without allowing the change to upset the temperature. The temperature controller has a much simpler job to perform and the quality of control is improved.

When possible, therefore, upsets of this nature should be corrected at the source by adding a controller at the proper point. The additional controller need not be a recording controller. Sometimes a pressure-balanced valve or a non-indicating controller will serve the purpose. The results will be far better than by adding all sorts of gadgets to the master controller because the master controller cannot detect the upsets until they have already affected the process.

Many times the upsets are in the form of changes in composition of the material being processed or changes in the heating value of a fuel, which cannot be readily controlled. It is then even more necessary to correct these upsets at the source.

An example of uncontrolled upsets is found in the following application. Pressure in a steel furnace was controlled with a furnace pressure controller and a damper. In the morning wide cycling of furnace pressure was observed. Much difficulty was caused until it was discovered that when the sun hit the building in the morning, the operators opened the shutters in the side of the building to cool the furnace room. The varying wind conditions created varying pressure loss conditions and frequent upsets caused the furnace pressure to cycle continually.

Control of final product is desirable. When impossible, more independent variables must be carefully controlled.

In many cases it is impossible, from the practical standpoint, to control the final product. In this case, more of the independent or outside variables must be carefully controlled so that their effect on the final product can be nullified.

For example, in many heat treating furnaces metal temperatures cannot be directly controlled. By controlling furnace temperature, furnace pressure, fuel pressure, and sometimes furnace atmosphere, however, the metal being treated can be held to fairly close limits.

In processes having extremely large capacity and large dead time, hours will sometimes elapse before a change can be completely detected. There is a limit to the lag through which any controller can maintain effective control.

Summarizing this discussion, there are many more problems in automatic control than just the controller itself. In any control problem the quality of control can be improved more by carefully analyzing the measurement and the process than by needlessly complicating the control system.

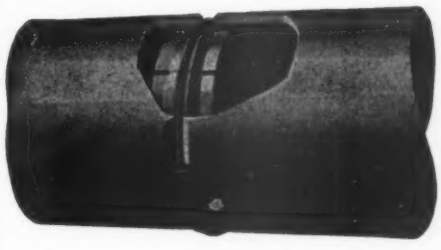
The points discussed here are worth a brief repetition.

1. *Keep measuring lag to a minimum.*
2. *Keep controller lag to a minimum.*
3. *Use sensitive measuring and control systems.*
4. *Connect outside variables at source.*
5. *Control from final product.*
6. *Properly maintain control system.*

★ ★ ★

WEDGE
CHILL RINGS
assure
100%
PENETRATION
therefore
STRONGER
Joints

The use of thin wall pipe is a great advantage when WEDGE Chill Rings are used to REINFORCE the joints which makes them stronger than the pipe. In case of settling or strain, the reinforced joints won't break. They also assure 100% PENETRATION of the ENTIRE pipe circumference. You can weld pipe FASTER with



WEDGE Chill Rings, they are FLEXIBLE and will adjust themselves snugly to the irregular diameter of unfinished inside surfaces of pipe. The alignment is practically automatic, the operator slips the second section on the ring without the use of clamps or guides. For any pipe welding job it will pay to use WEDGE Chill Rings.

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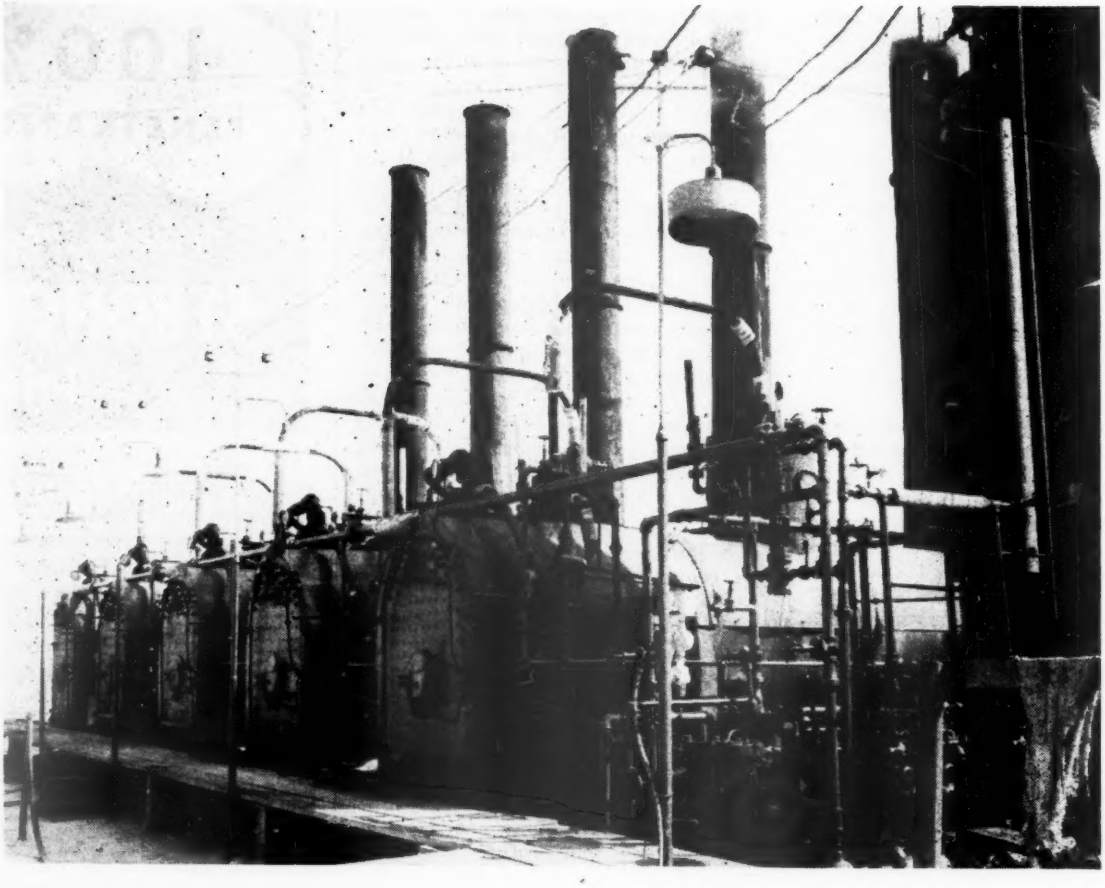
On The Beam With Lucey Steam!



In congratulating Standard Oil Company on its achievement in setting a new record for the world's deepest well in the Cole Levee Field, California, we take pride in the fact that this battery of five Lucey Oil Country Boilers was used in drilling this well.

Lucey Oil Country Boilers are serving in many fields of the world, in many climates and under all kinds of operating conditions. . . and doing a good job.

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NEW WORLD'S DEPTH RECORD SPOTLIGHTS EFFICIENCY OF DRILLING TECHNIQUE

By **WALLACE A. SAWDON,** *Pacific Coast Editor*

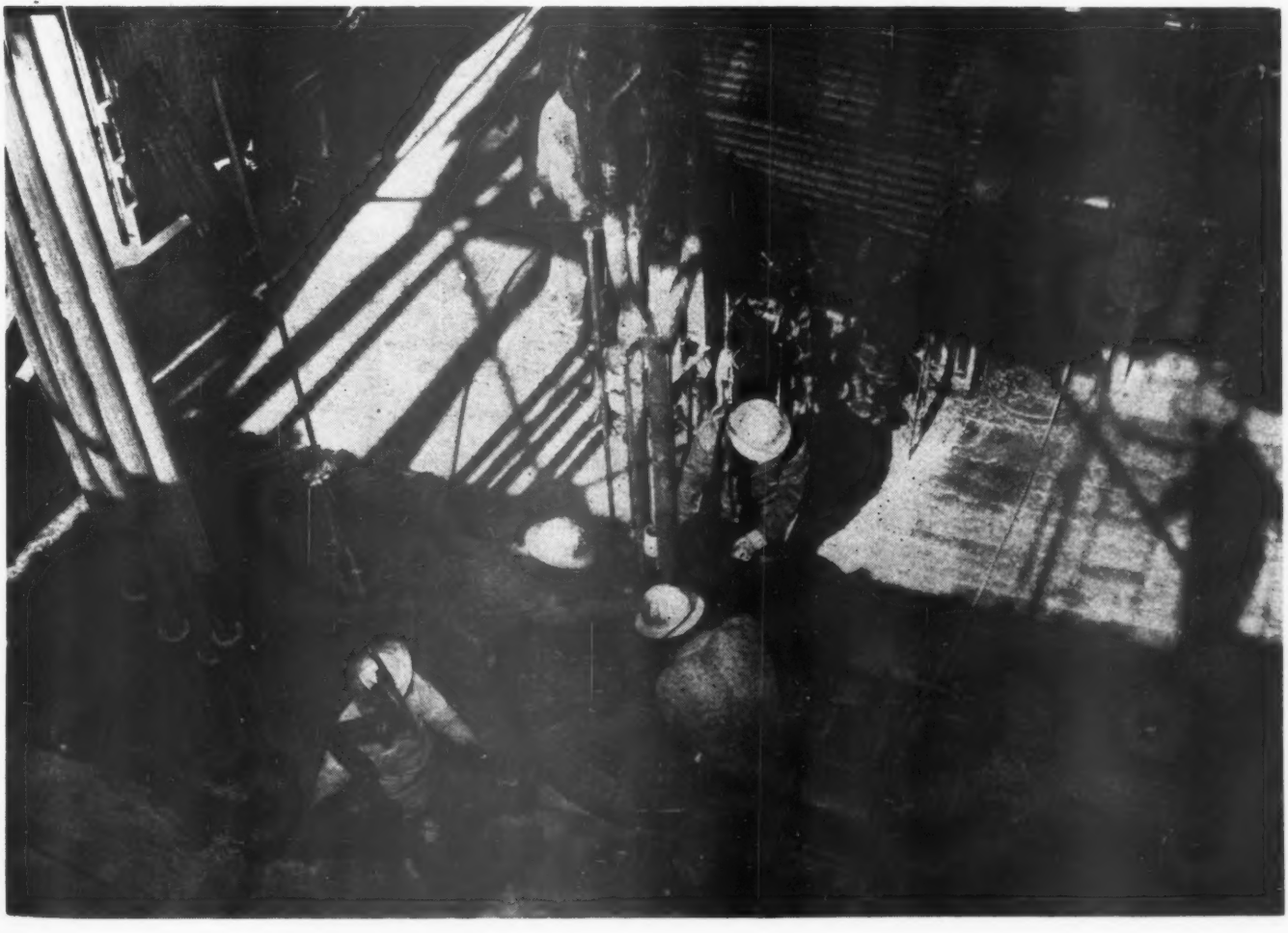
EXCLUSIVE THE third well to be drilled to a depth greater than 15,000 ft. and the second to break the world's depth record during the year, Standard Oil Company of California's well KCL 20-13 in the South Coles Levee field of the San Joaquin Valley, Kern County, California, is still drilling ahead at 15,845 ft. Of particular interest in this operation is the use of equipment that is available at this time, little if any of which can be considered new either from the standpoint of design or purchase date.

The well, spudded in on July 31, 1943, was intended from the beginning to penetrate to great depth in order to explore deep zone possibilities and it was therefore known that good drilling technique would be a vital factor in reaching the objective. None of the equipment is of the exceedingly heavy or "super" types that have been employed in drilling a number of wells in California, but is of the same type and size as the other so-called heavy steam outfits being operated by the company for its deeper drilling throughout the state. The results obtained have thus been a tribute both to the skill and experience of the drilling crews, technical personnel and management, and to the manufacturers of the equipment, which has proved its ability to meet the demands of great depth when properly utilized.

The first well ever to reach 15,000 ft. was Continental Oil Company's A-2 at Wasco, which held the world's record at 15,004 ft. from 1938 until early this year when Phillips Petroleum Company's well Price No. 1 in Pecos County, Texas, was drilled to a total depth of 15,279 ft. Formational conditions naturally differ in the three 15,000-ft. wells, particularly between the one in West Texas and the two in California, and these conditions necessitated different casing programs. As a matter of interest, the pipe run in the two completed wells and that run to date in the Coles Levee well are shown in Fig. 1. The formations encountered and experience in drilling these formations have permitted the minimum use of steel in the well now drilling.

The Coles Levee well is, of course, part of the intensive program to discover new crude oil production for war needs and to increase the known reserve of the state. The well is located in Sec. 5, Twp. 31 S, Range 25 E. and is approximately three-quarters of a mile to the west of the present producing limits of the South Coles Levee field. Wells in the area in which it is located produce from the Stevens zone of Miocene Age at approximately 9000 ft.,

Looking downward to the derrick floor where the crew is pulling casing to change a bit.



but below this zone are possibly other productive horizons such as the Vedder sand, which is productive at much shallower depths along the east side of the San Joaquin Valley.

No serious fishing jobs have been encountered and little trouble has been experienced in drilling the well, which reached a depth of 14,000 ft. in a little less than 11 months after being spudded in. The drilling progress from that depth on is shown graphically in Fig. 2. It will be noted that progress was retarded from 14,800 ft. to nearly 15,000 ft. The formations in that interval were extremely hard and in many cases only 1 ft. could be drilled with a bit. The effect of drilling 3 ft. of this formation on one bit is shown in the illustrations. At that time it was taking a little less than 8 hr. to make a round trip to change bits, about 3½ hr. to come out of the hole, and about 4 hr. to go back in. The trip time has naturally increased with the greater depth attained, between 170 and 180 90-ft. stands now having to be handled in making each trip.

The hole has been kept in exceptionally good shape throughout its entire depth. Verticality is controlled by frequent checks of inclination made by running an inclination recorder capable of measuring small angles accurately and thus determining any inclination in fractions of a degree. The hole has at no time been off vertical more than 3 deg. The drilling control instrument is a bobtailed "sealtite" type of weight indicator with mud pump gauge, torque gauge and tachometer, but is hooked up according to the company's own plan. The mud pump pressure, steam pressure, and rotating speed of the table as well as the weight being carried on the bit can therefore be controlled at all times and the ratio between weight and table speed varied intelligently to obtain most efficient drilling in the different kinds of formations.

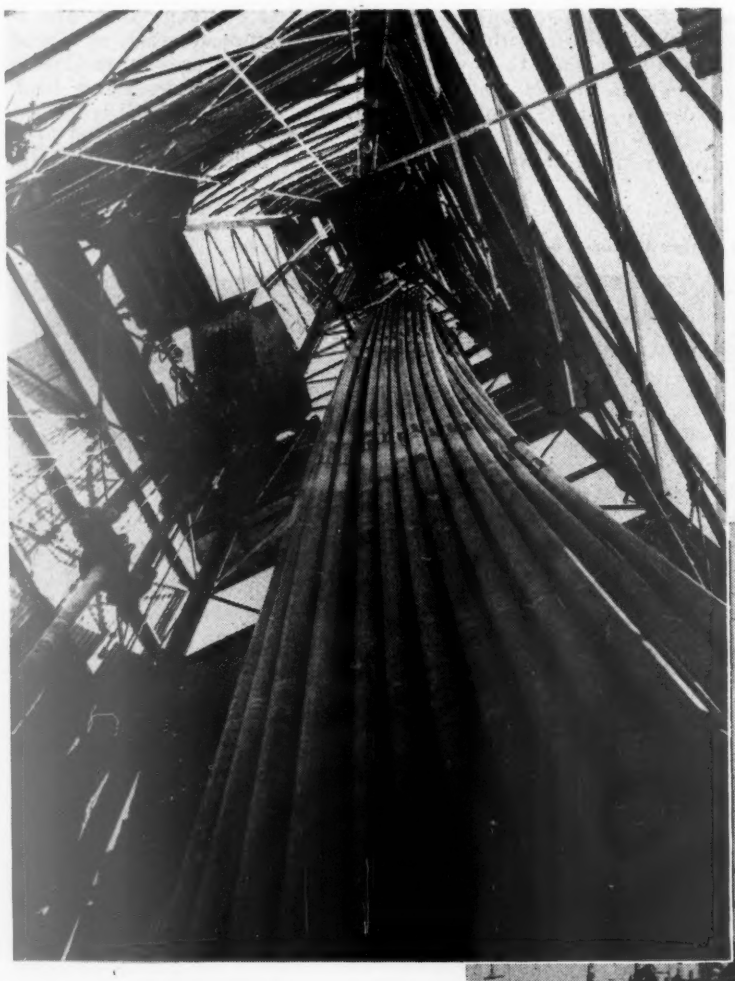
Mud weight has been maintained by addition of weight material and at the shallow depths it ranged from 78 to 80 lb. per cu. ft. While drilling through the Stevens zone it was maintained at 82 to 84 lb. per cu. ft., but at the present time, while drilling below 15,000 ft., it is kept at 90 to 93 lb. per cu. ft. with a viscosity of 45 sec. The returns are screened by two shakers set in parallel, both of which are belt driven by 3-hp. explosion-proof electric motors.

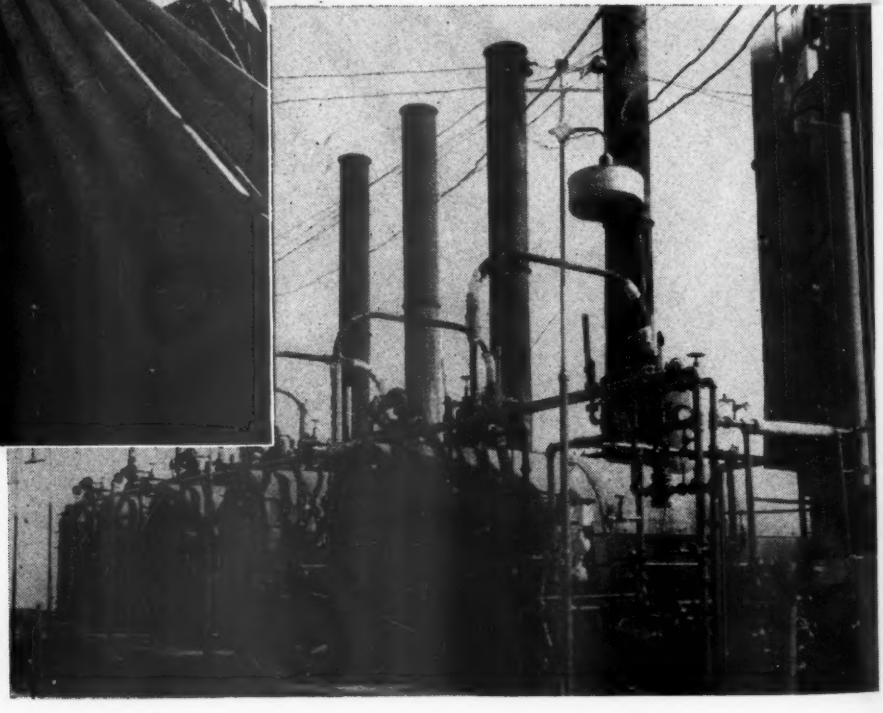
The mud is tested at desired times for wall building qualities, water loss, viscosity, pH, etc. At one point where oil and gas were found in the returns, the mud was treated with quebracho and tetrasodium pyrophosphate to control viscosity. To remove gas from the mud it is passed over a "fisher-ladder" type degassing tower made in the company shop.

The mud is circulated by two pumps, an 18 in. by 8 in. by 20 in. and a 16½ in. by 7¾ in. by 20 in. These have a lift suction and are manifolded for compounding. The suctions are 10-in. and a union with blind flange is used for compounding. Valves in the high pressure discharge are 4 in. A 14 in. by 7¼ in. by 14 in. pump is used for

(Continued on Page 95)

Standard Oil Company of California's KCL 20-13, South Coles Levee field, has surpassed all previous wells for depth—now drilling at 15,845 ft.—a part of program to find new production for war needs.





Above—**Drill pipe stand in well KCL 20-13.** *Right*—**The boiler plant consists of five 100-hp. locomotive type boilers, four of 250 lb. per sq. in. working pressure and one of 300 lb.**

(Continued from Page 88)

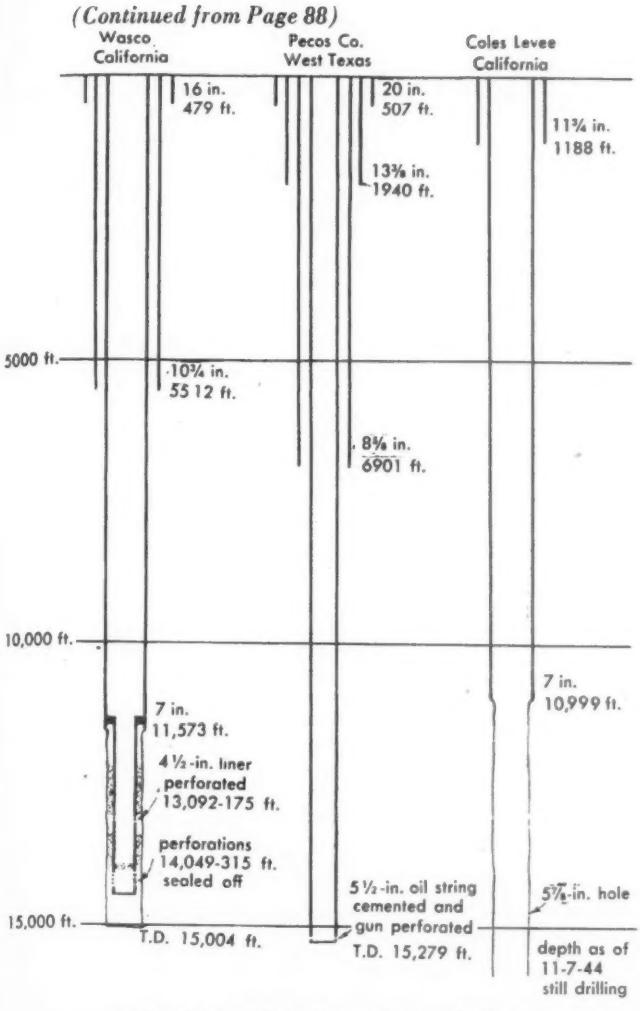
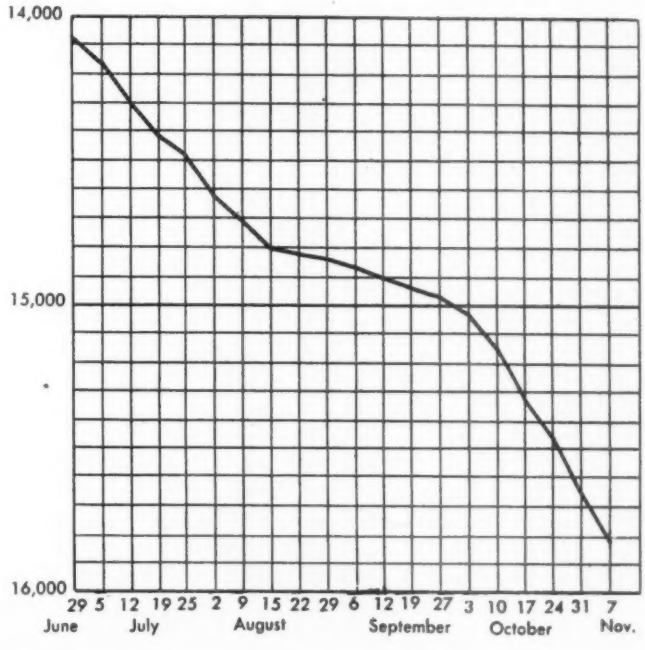
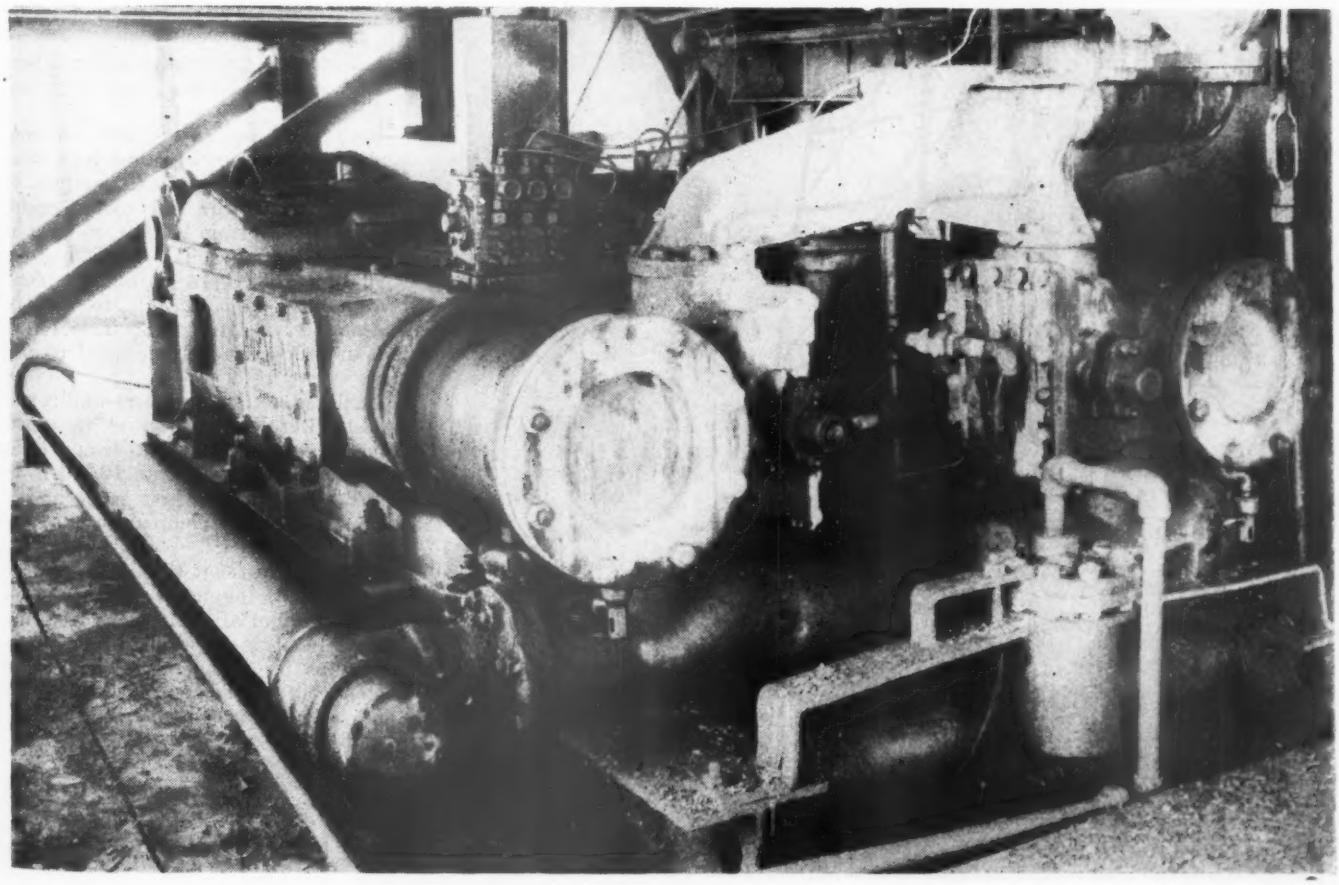


Fig. 1. *(left)*—**The casing program of the three wells drilled to below 15,000 ft. are shown in this sketch.**

Fig. 2. *(below)*—**Weekly drilling progress of well KCL 20-13 after passing depth of 14,000 ft.**

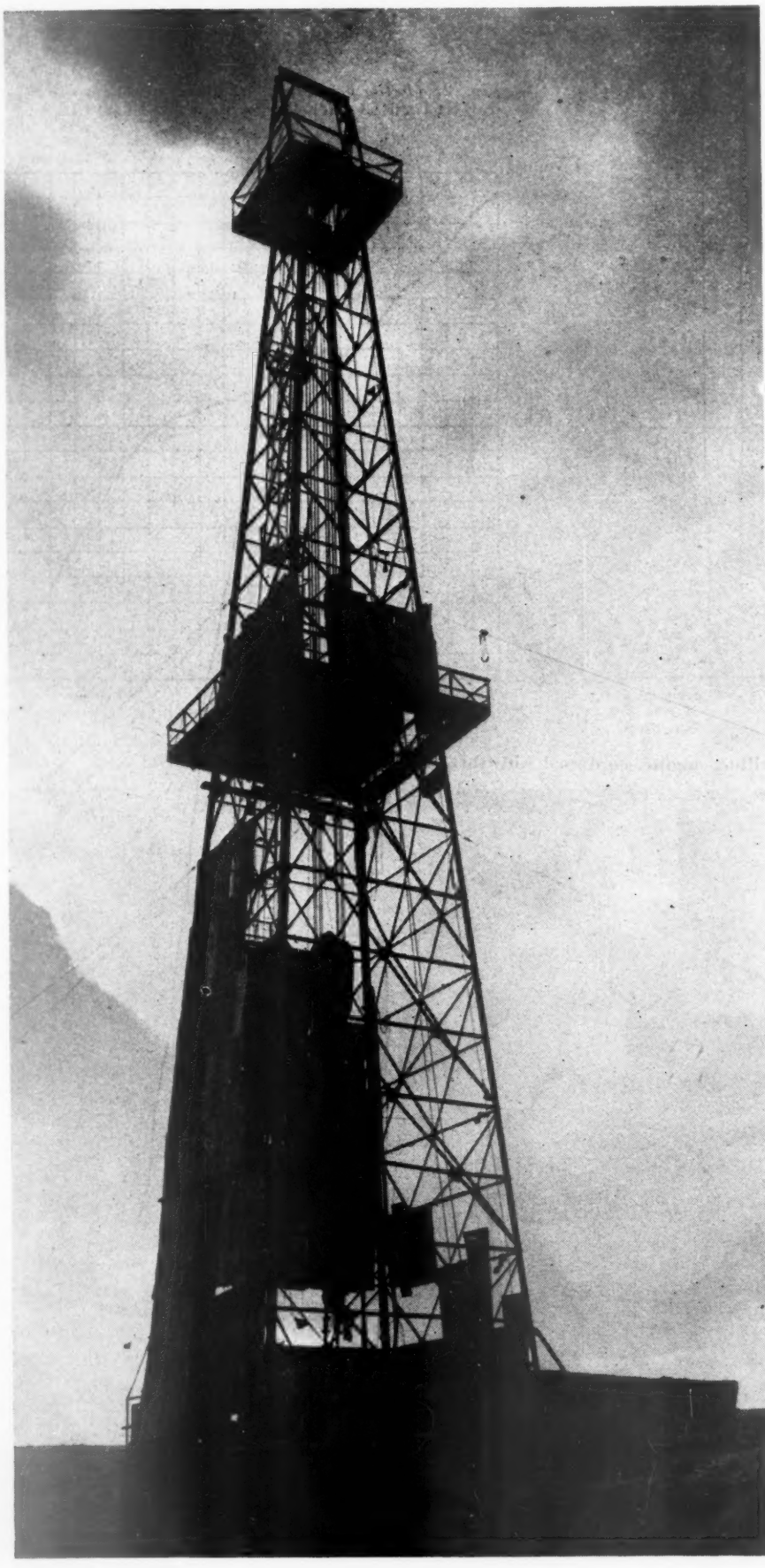


The 12 by 12 horizontal twin drilling engine, equipped with throttle valve and quick shut-off valve.



mud mixing and for general utility in moving the mud fluid. A 14 in. by 6¾ in. by 14 in. is used for pumping the mud over the degassing tower.

A 15½-in. hole was drilled to 1188 ft. where 11¾-in. casing equipped with slip joint float shoe was cemented with 600 sacks of construction cement, all of which was displaced around the shoe. From that point 10⅝-in. hole was carried to 10,999 ft. and a string of 7-in. casing cemented with 1000 sacks of high temperature cement. This string was made up with a J-55 float shoe on bottom and an N-80 float collar above the shoe joint. Although no bottom-hole temperature surveys have been made to date the company estimated the temperature at the 7-in. casing seat at approximately 270° F. The top of the cement outside the 7-in. string was estimated to be at approximately 8500 ft. and was thus above the top of the Stevens zone. The seat for this string of casing was selected by data provided by electrical log.



Two 9⅝-in. cellar control gates with a blowout preventer above provide safety features in case of emergency. These have manually operated remote control. One of the gates is equipped with rams to pack off around the 3½-in. drill pipe and the other with blind rams for complete shut-off. The casing-head is a 13⅜ in. by 7 in. full opening type with slip over for welding.

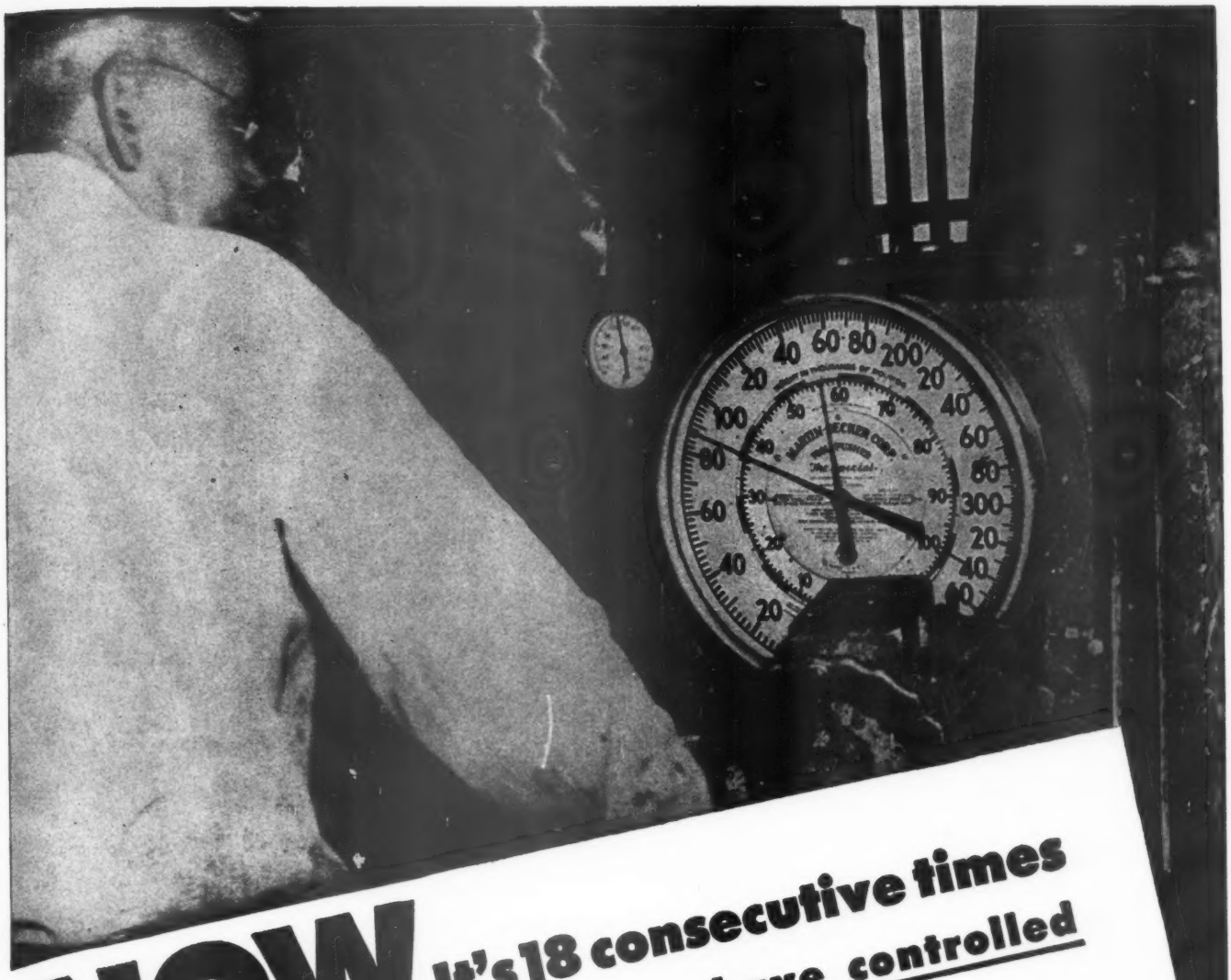
The drill pipe being used for the deep drilling is all 3½ in. diam. The top 49 stands (approximately 4300 ft.) are made up of 15.5-lb. pipe with I. F. joints. The next 111 stands (approximately 9900 ft.) are of 15.5-lb. pipe with slim hole joints. This pipe was originally purchased as I. F. but was later converted to slim hole by having the I. F. joints cut off and slim-hole joints pressure-welded on. The bottom stands consist of 13.3-lb. pipe with slim hole joints. The drill pipe extending through the 7-in. casing is equipped with 5¼-in. casing protectors installed at about one protector per stand of pipe. Three drill collars are in service, all being 4½ in. O.D. by 30 ft. with 2¼ in. by 3¼ in. by 5 in. box both ends. A reamer has been used above the bit and rock bits of several designs have been employed.

Both wire line coring and the conventional core barrel method have been used to procure physical samples of formation. The wire line coring equipment was used from 9213 ft. to 9590 ft. and the conventional method from 9590 ft. to 14,710 ft. Coring was done continuously from 9213 ft. to 9686 ft. and at intervals from 9736 ft. to 14,710 ft. Core recovery has averaged 65 per cent.

Analyses of cores for permeability and porosity were made on cores recovered from 9213 ft. to 10,309 ft., from 11,976 ft. to 12,530 ft., and from 12,940 ft. to 14,073 ft., all but the first group having been made in the company's own production laboratory.

Up to the present time four runs of the electrical logging equipment have been made and all formations from the shoe of the 11¾-in. casing to 13,538 ft. have thus been logged. It can be expected that an electrical log to total depth will be run when drilling is completed.

Standard's well KCL 20-13, South Coles Levee field, California, which has broken the deep drilling record.



NOW It's 18 consecutive times Martin-Decker Instruments have controlled a record-breaking well!

THIS business of furnishing control instruments for world's record wells is becoming a fixed habit with Martin-Decker. For over 18 years in every country in the world where a new depth record has been established, Martin-Decker's drilling control instruments have been used.

Every foot of Standard Oil Company's K.C.L. 20-13 was controlled with a Martin-Decker Weight Indicator.

Riding herd on 3 miles of twisting steel is a tough job. But whether you go deep or shallow, there's a Martin-Decker instrument made to meet your drilling needs. To complete better wells, make your choice MARTIN-DECKER DRILLING CONTROL INSTRUMENTS.

HOME OF THE WEIGHT INDICATOR

MARTIN DECKER CORP.

LONG BEACH, CALIFORNIA

SAN JOAQUIN VALLEY: A. F. McQUISTON, BAKERSFIELD, CALIFORNIA
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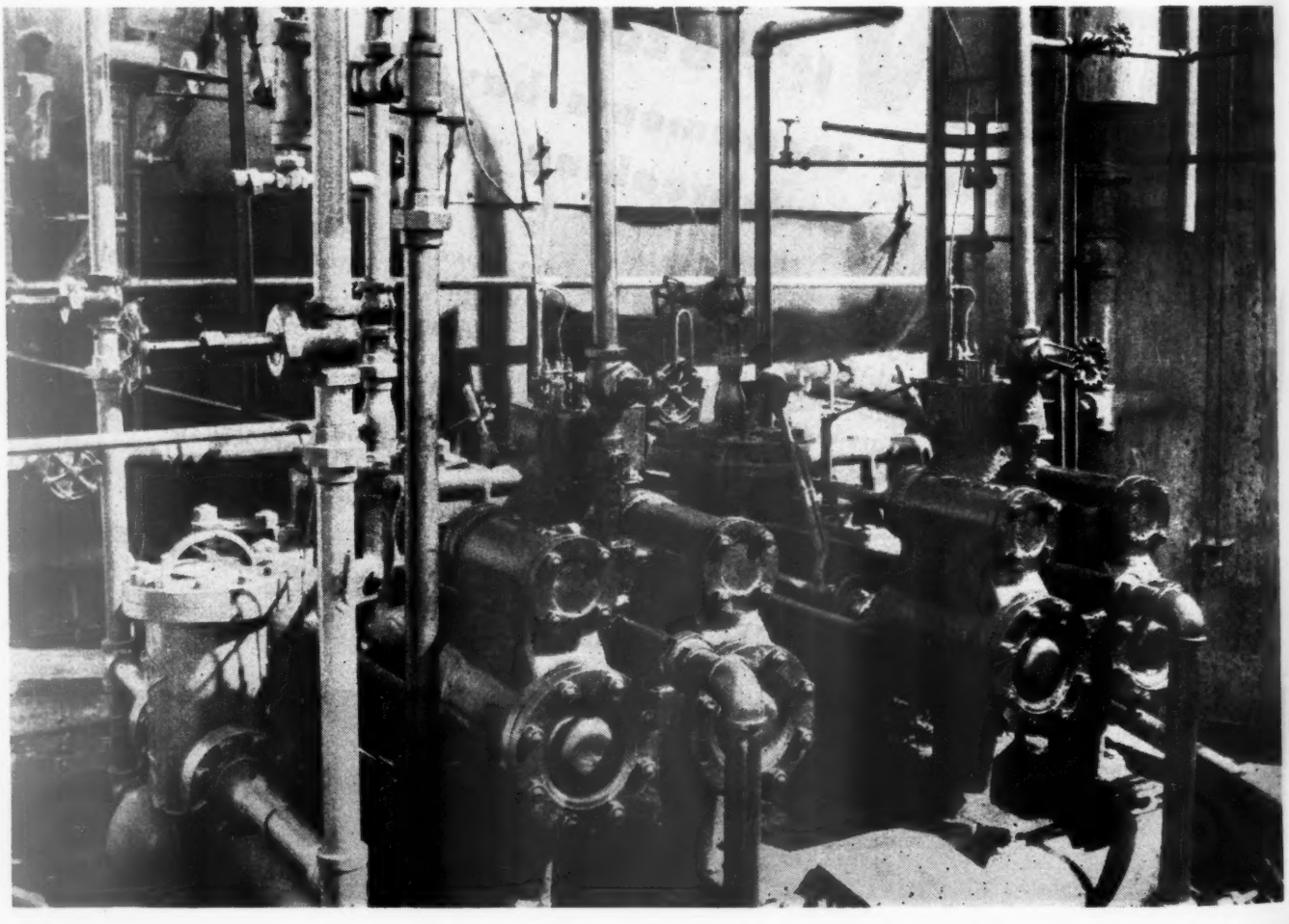
Weight indicator is shown to the right and hydromatic brake to the left of Driller Fred B. Snyder.

Boiler feed water pumps on the Standard well consist of 7-in. by 4½-in. by 10-in. units.



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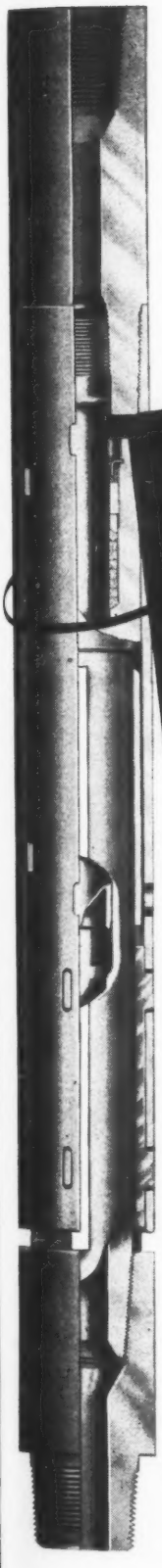


WHEN PIPE STICKS

here's the tool that gives the *split-second action* you need!

THE BAASH-ROSS DRILLING TYPE BUMPER SUB

WHEN a drill string sticks—or threatens to stick—what you do in the first two minutes of the emergency generally decides whether you're going to recover the pipe right away . . . or have a costly risky fishing job on your hands. If you have provided no means of immediately jarring the string loose, chances are by the time you have released from the stuck portion, come out of the hole, put on a fishing tool and gone back into the hole again, the stuck section will be so firmly packed with settled cuttings that a long and costly cut-and-fish job is the only way out.

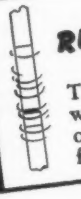
But here's how to safeguard against such emergencies. When you make up the drill string, run a Baash-Ross Bumper Sub above the bit, the reamer, or other point likely to stick. Then when trouble threatens, you can go into *instant* action to free the pipe. You can act before cuttings have a chance to settle around the stuck section. You can jar *up* . . . or you can jar *down* . . . or you can alternate up and down blows. And you can instantly vary the intensity of the blows to suit conditions without rotating the string or in any other way adjusting the tool!

With the split-second action this Bumper Sub provides you can generally free stuck pipe in a minute or two—before it has had a chance to become tightly packed in place. You can prevent costly fishing jobs and can drill with much greater safety—particularly in sticky or heaving formations.

Check over the important features outlined here. Then get in touch with your nearby Baash-Ross representative for full details on the many important ways this tool can serve you. Available in a complete range of sizes from 2⅞" thru 6⅝", both Regular and Full Hole!

(Leased in U. S. A.—Sold for export only.)

RUNS IN THE DRILL STRING!



The Drilling Type Bumper Sub is specially built to withstand the rugged service of heavy duty drilling operations. You can run it right in the string ready for *instant* action when trouble threatens.

DRIVES EITHER UP OR DOWN!

By simple manipulation of the drill string you can strike either upward or downward blows—or can alternate up and down blows—whichever is needed. This versatility gives a choice of actions for every requirement!

SPLIT-SECOND ACTION!

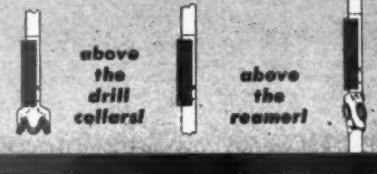
As soon as the pipe sticks—or shows signs of sticking—you can go into immediate action with the Baash-Ross Bumper Sub. Nothing to set. Nothing to release. No delays!

BLOW INSTANTLY VARIABLE!

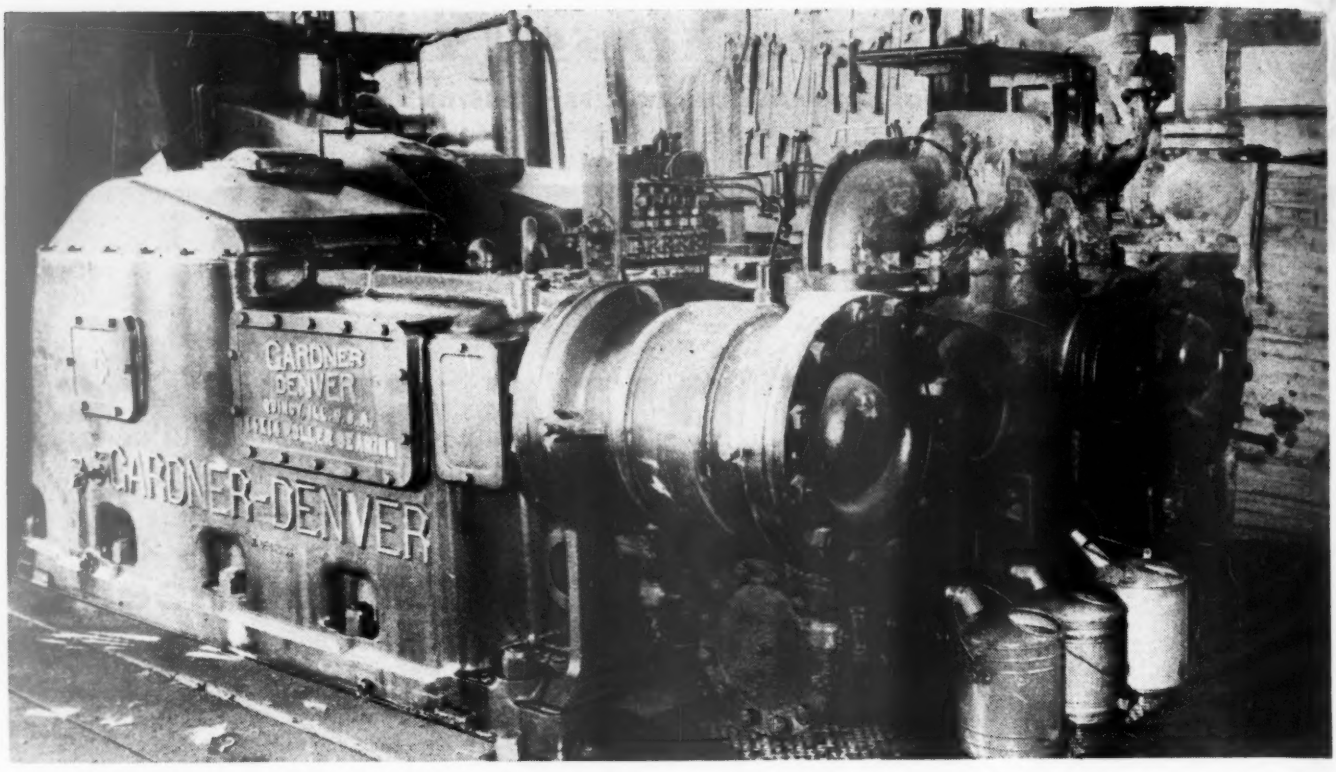
Another important point—the tool requires no adjustment to vary the intensity of the blow. The force of the blow—either up or down—can be instantly regulated at the surface to fit the job.

WHERE TO USE THE BUMPER SUB!

Run it directly above wherever you're likely to stick the string . . .



. . . or at any other point where you want to concentrate a solid blow in an emergency!



Hoisting engine, 14-in. by 14-in. horizontal twin.

▶ **Surface equipment.** Operations are being conducted with a 136-ft., unreinforced, silicon-steel derrick with 30-ft. base and extended legs. The rated capacity of the derrick is 799,600 lb. and at the present time the total weight of drill pipe and accessory equipment supported by the derrick is approximately 250,000 lb., possibly a little more. The substructure is a marketed type with company modifications and is 8 ft. 3 in. high.

The crown block has seven 48-in. diam. sheaves grooved for 1¼-in. wire rope and is designed for 360 tons dead load. The traveling block is a 121-in. type with six sheaves grooved for 1¼-in. wire rope and rated at 500 tons dead load capacity. The casing lines being

Proper mud weight was maintained at all times.

Coming out of the hole at 15,065 ft.

used are 1¼-in. by 2750 ft., grade "J." Various makes have been used at random.

The hook is a 300 ton triplex with duplex type body used for drilling on the links. The elevator links are weldless 2¾ in. by 108 in. Three 3½-in. elevators are in service, two for I. F. drill pipe and one for slim-hole drill pipe as used with lifting plugs. The swivel is of 300-ton capacity equipped with bail adapter for drilling on the links. Two 2½-in. by 55-ft. rubber rotary hose are on the rig, one being used as a spare and both having swing joints on the swivel end.

The drawworks has 54-in. brake rims and 10-in. drumshaft with grooved drum and water-cooled brake rims. This equipment as purchased was equipped with sprockets for API No. 4 chain but later was converted by the company to dual 3⅛-in. pitch sprockets and chain throughout. All chains are drip lubricated except the engine drive chain, which is oil bath. The drawworks is equipped with automatic cathead, catline grip, rope guards, and one wire line turn back roller on the driller's side. Two 36-in. single hydromatic brakes are used, one mounted on each end of the drawworks drumshaft.

The drawworks and hoisting engine are mounted on a 7 ft. 6 in. high combination base made by the company. The engine is a 14 in. by 15 in. horizontal twin, has a 4-in. throttle valve, 4-in. quick shut-off valve, and is equipped with a steam reverse kicker.

The rotary machine is 20½ in. table opening and has rated capacities of 250 tons under dead load and 125 tons under rotating load. A make of master bushing and pin drive kelly bushing different from that of the rotary machine is being used. The drill pipe slips are of the cluster type. The kelly is 4½ in. square with 38 ft. working space. It is equipped with a 3-in. stopcock.

The rotary machine is powered through an underfloor drive by a 12 in. by 12 in. horizontal twin engine set below the derrick floor. This engine is equipped with a 4-in. throttle valve and 4-in. quick shut-off valve for safety shut off.

A 5-ft. calfwheel is used for dead ending the line and not for standby. The calfwheel is chain driven by a 12 in. by 12 in. single-cylinder engine for convenience in handling casing line. The sand reel is powered by the same engine as that used for the calf-wheel.

The boiler plant consists of five 100-hp. locomotive type boilers, four of 250 lb. per sq. in. working pressure, and one of 300 lb. per sq. in. The boilers are insulated, have continuous blowdowns and 28-ft. stacks that have automatic jets controlled by steam line pressure. The boilers are fired by gas burners and are equipped with fire-box type superheaters. Other accessory equipment includes water level controllers, an open type feed water heater, and water softener. The feed water pumps are 7 in. by 4½ in. by 10 in. The boilers themselves are all equipped with reflex gauge glasses, tri-cocks, level control valves, and blow-off valves of standard design.

▸ **Probable completion methods.** If commercial production is discovered in the objective zone, the well will probably be completed either by cementing blank liner and gun perforating or by landing a combination liner and cementing through perforations. The present intention is to continue drilling until oil is found or until the safe limit imposed by the equipment is reached. It is believed that this limit will be at approximately 16,500 ft.

▸ **Manufacturers of equipment.** The following equipment was used on the well:

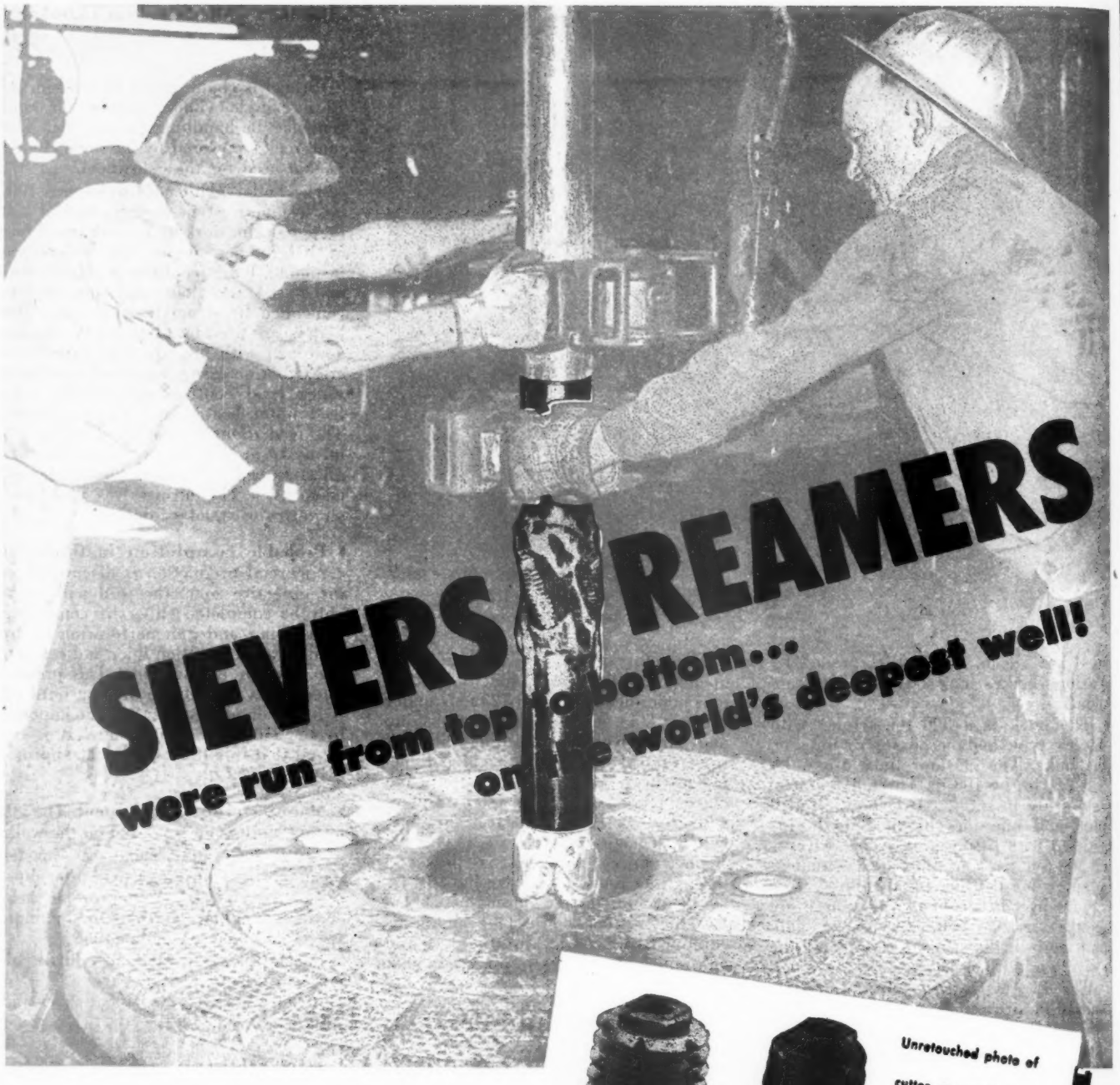
Abegg & Reinhold Company—master bushings, kelly bushings, drill pipe slips.

Ajax Iron Works—steam reverse kicker, drilling engine, auxiliary mud pumps, swivel bail adapter, and engine.

Baash-Ross Tool Company—drill collar clamps, kelly, drill collars.

Baker Oil Tools, Inc.—float shoes and collars.

The hardness of some of the deep formations penetrated is indicated by these two views of bits. To the left is bit before being run into the well. To the right, after drilling 3 ft. of hole from 14,865 ft. to 14,868 ft.



Unretouched photo of cutter removed from Sievers Reamer below 15,000 feet. Compare this with the new cutter shown at left and note evenness of wear.

SIEVERS REAMERS were run from top to bottom on Standard's K.C.L. 20-13, world record well—and this hole was never more than 3% off vertical. *Sievers Reamers' wider wall contact gives full hole stabilization.*

SECURITY ENGINEERING CO., INC.

HOUSTON
ODESSA, CONROE
TEXAS

WHITTIER
BAKERSFIELD-VENTURA-AVENAL
CALIFORNIA

NEW YORK
CENTRALIA
ILLINOIS

CASPER
WYOMING

Baroid Sales Div., National Lead Co.—drilling mud.

Byron-Jackson Company — hook, elevator links, catline grip, rope guards, drill pipe tongs.

Chiksan Tool Company—swing joints.

Consolidated Steel Corporation—derrick.

Crum-Brainard Co., Ltd.—bits.

Edwards Wire Rope Company—casing line.

Emsco Derrick & Equipment Co.—derrick substructure, drawworks, rotary machine, sand reel.

Everlasting Valve Company—blow-off valves.

Gardner-Denver Company—hoisting engine, mud circulating pumps, auxiliary mud pumps.

General Electric Company — electric motors.

Globe Oil Tools Company—finger board.

Grizzly Mfg. Company—wire line turn-back roller, rotary hose, line savers, casing protectors.

Hamer Oil Tool Co.—kelly cock.

Hydril, Inc.—drill pipe joints.

Hughes Tool Company—bits, coring equipment (wire line).

Jerguson Gage & Valve Company—reflex gauge glasses.

Jones & Laughlin Steel Corp.—drill pipe.

Kerotest Mfg. Co.—throttle valve.

Link-Belt Company—mud screens.

Lucey Boiler & Mfg. Corp.—locomotive type boilers.

MacClatchie Mfg. Co.—gearomatic automatic cathead, monkey board.

Martin Decker Corp.—weight indicator with mud pump press, gauge, rotary table (tachometer) and steam press gauges.

Merco Nordstrom Valve Co.—valves.

National Supply Co.—drill collars.

National Tube Company — drill pipe.

Natural Gas Equipment Company — gas burners.

Oil Well Supply Company — swivel. mud circulating pumps.

Parkersburg Rig & Reel Co.—hydromatic brakes.

Patterson-Ballagh Corp.—drill pipe wiper.

Permutit Company—water softener.

Reed Roller Bit Co.—bits, blow-off valves.

Regan Forge & Engineering Co.—bag packer, crown block, traveling block.

Schlumberger Well Surveying Corp.—electrical log.

Security Engineering Company — Sievers reamers.

Shaffer Tool Works—blow-out equipment, casinghead.

Spang Chalfant, Inc.—drill pipe.

Technical Oil Tools—well surveys.

Thornhill-Craver Co.—Unibolt union.

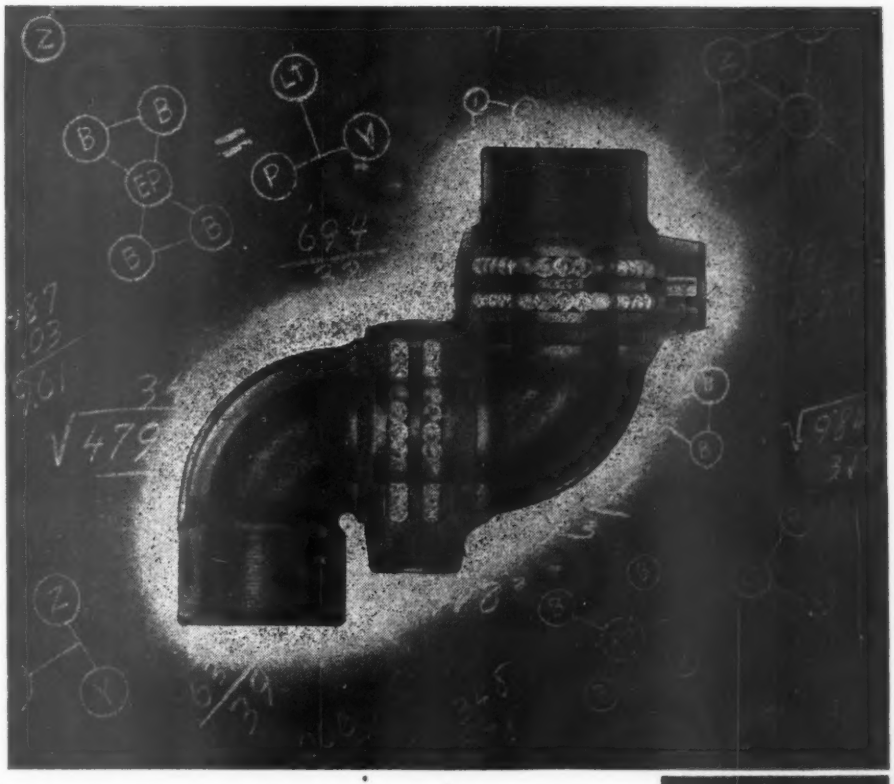
Victor Cement Co.—cement.

Web Wilson Co.—elevators.

Wilson Snyder Mfg. Div.—boiler feed water pumps.

Youngstown Sheet & Tube Company—drill pipe.

★ ★ ★



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EP = Effective Packing Element
P/V = Pressure or Vacuum
LT = Low Torque under all conditions.

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P 442.9

PROSPECTS FOR DEEPER ZONE PRODUCTION IN CALIFORNIA

By **ALBERT GREGERSEN** *and* **FRANK S. PARKER**
Petroleum Administration for War, District 5

THE demand for California oil to wage the war in the Pacific is so enormous that means must be found, if possible, to accelerate this state's rising rate of crude oil production, to the end that the armed forces in this theatre of operations may continue to be assured of ample supplies of petroleum products, when and where needed.

Even at its present high rate of crude oil production the California oil industry is required to draw heavily on inventories to meet combined military and essential civilian demand on the Pacific Coast. These inventories have now declined to the point where they can no longer be counted on to supplement production in any appreciable quantity.

Although it is true that an aggressive wildcatting campaign has contributed to the state's reserves of oil, production is still not in sufficient volume to bring the state's output in balance with consumption. It appears highly important, therefore, that the industry in California test thoroughly and promptly the possibility of deeper zone production in existing fields.

In order to assist and encourage operators to prosecute an intensive deeper zone exploratory program, the Petroleum Administration for War, District 5, Production Division, has sponsored a thorough investigation of deeper zone possibilities and the data developed are presented in this article.

In exploration for deeper zones, one of the principal factors necessary for accumulation of petroleum, namely, favorable structural conditions, has already been proved by the original discovery of the field in which the deeper zone test is to be made. That the risks involved in this type of exploration are smaller than in wildcatting for a new field is convincingly shown by the relatively high percentage of success of deeper zone tests.

Granting that the structural hazard has been materially reduced in deeper zone tests, the most important problem is whether or not sediments with favorable reservoir characteristics and suitable source beds are present under the field where the deep test is to be drilled.

If the objective deeper strata have produced petroleum in other fields located in the same sedimentary basin, the hazard is still further reduced. Then the principal problem becomes one of local distribution, character, and extent of the prospective strata within the basin itself.

For the purpose of this study the accompanying charts were prepared showing the oil fields of the state. On these are indicated the age of the oldest formation outcropping in the field, the position in the geologic section of the producing zones, the deepest stratigraphic penetration within the field and the depth of the deepest well drilled.

Most of the data included in the charts are available from published material, but it is believed that the compiled charts will be of interest and assistance to operators looking for deeper zone prospects and will be of value for reference.

The charts have been divided in a manner to cover fields grouped on geographical or geological relationships. In the case of the San Joaquin Valley, the fields are divided into three groups for convenience. Index maps show the location of the fields by a serial number referring to a number on the chart. In some cases a group of several small fields have been included under one number where stratigraphic conditions within those fields are similar and located relatively close together.

The depth of the deepest well drilled in each field is included on the chart to indicate among other things whether drilling depths for deeper prospective zones would be mechanically feasible. It should be pointed out, however, that the greatest depth reached in a field is not always at the best structural position. For this reason depth is not always significant. Likewise it should be pointed out that the deeper prospects of a field have not necessarily been condemned by unsuccessful stratigraphic penetration below the lowest producing zone. Assymetry, rapid stratigraphic changes, unconformities, and other geologic anomalies may be responsible for the failure of deep tests drilled to date in the field.

A number of points with reference to deeper zone prospects stand out.

1. Eocene formations appear to offer most of the untested prospects for deeper zone production in California. That the Eocene is productive of oil and gas has ben proved in several fields in the San Joaquin and Sacramento Valley basins as well as in the Ventura Basin. Showings of oil in formations of Eocene age have been encountered in wildcat wells in the Santa Maria and Los Angeles basins, although no commercial production has yet been obtained in these areas. A study of the charts will show that there are many fields in which the Eocene has not yet been reached.

2. Commercial production of gas has been obtained from beds of Cretaceous age in a number of fields in the upper San Joaquin Valley and Sacramento Valley. Oil has been produced commercially from the Cretaceous at Coalinga (Oil City). Showings of oil have been encountered in a number of wildcat wells on the west side of the San Joaquin Valley north of Coalinga. Although the showings and production from Cretaceous are not as extensive and important as from the Eocene there still remain possibilities of deeper zone production wherever a sedimentary section of Cretaceous age, similar to the Oil City section, underlies a known productive structure. This would apply particularly to the San Joaquin Valley.

3. Production from fractured or weathered "basement" rocks may be a deeper zone possibility that may be of considerable importance. There are already some fields in which this type of production is or has been of some consequence, notably El Segundo, Del Rey, and more recently Santa Maria Valley. It is not unlikely that where favorable conditions exist as to porosity of "basement" rocks and source character of overlying sedimentary beds, production may well be obtained from "basement" rocks underlying a number of fields in California.

Deeper zone prospects of interest in particular fields are discussed below. The number shown with each field's name is the reference number assigned to that field on the charts. The data presented on these charts and comments are believed to be up to date as of July 15, 1944.

Los Angeles basin. A number of fields in the Los Angeles Basin have not completely penetrated the Miocene section. Although most of the Miocene production has thus far been obtained from the uppermost Miocene, as the chart shows, it is not unlikely that if the entire Miocene section had been explored in all the fields the picture might have been different. In two instances production has been obtained from the Middle Miocene (Puente 10 and Inglewood 18).

A wildcat well immediatey outside the producing area of Buena Park (8) penetrated several hundred feet of Eocene sands with very low permeabilities. Although the sands had good showings of petroleum they failed to produce on formation tests probably because of the low permeabilities. The presence of petroleum in these sands does indicate deeper possibilities in Los Angeles Basin fields located in areas that may be underlain by Eocene sediments. From our present knowledge of the geology of the Los Angeles Basin, those in the northeastern part would be most likely to have Eocene prospects. As indicated on the chart, a number of the fields in the southwestern part of the Basin have already reached the basement (Jurassic ? Franciscan) without encountering any Eocene (18, 20, 21, 24, 25, 26).

The followir.g brief comments relate specifically to deeper prospects of fields in the Los Angeles Basin:

Kraemer (10) and *Richfield (3)* may both have Eocene possibilities.

Brea Olinda (5) appears to have un-

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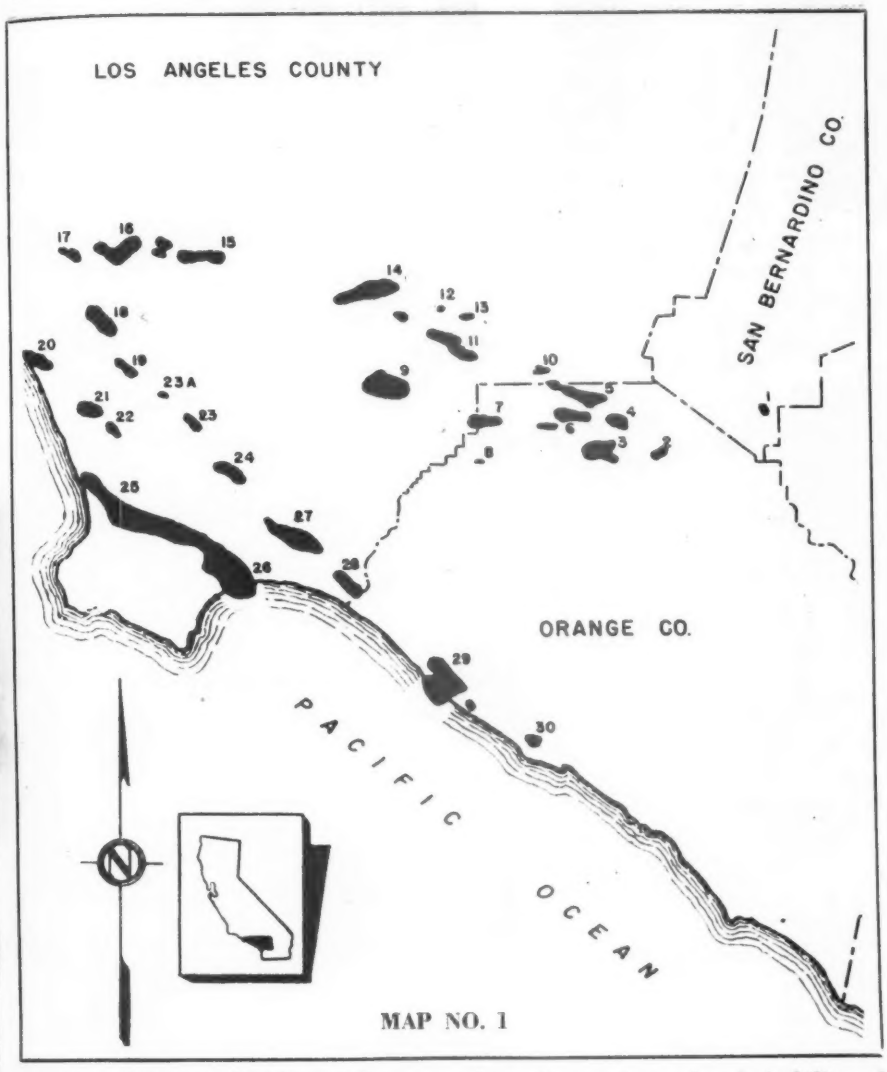


MAP NO. 1

tested possibilities in Middle and Lower Miocene and Eocene.

East Coyote (6) appears to have been tested through the Lower Miocene, although some doubt exists as to the conclusiveness of the test. Due to faulting the structural conditions in this field are very complicated and the deep test may not have been located at the best structural position. Eocene may be present under this structure.

In *West Coyote (7)* the entire Miocene Section has not been penetrated as far as available information indicates. Possibilities may be present in both Lower Miocene and Eocene under this field.

Buena Park (8). Deeper prospects in this field would lie outside the present area of production due to overlap conditions. A test is now being drilled to explore such possibilities.

Santa Fe Springs (9). One deep test, Union's Bell No. 100, penetrated a thick section of uppermost Miocene strata. The part of this section lying below present production was low in permeability. The structural location of the test was good. A thick section of Miocene and possibly Eocene should be present below strata penetrated by Bell No. 100.

Puente (10). If Eocene sediments are present under this field there may be some possibility of deeper production. Structural conditions and production to date detract from the desirability of deeper prospects.

Whittier (11) and *West Whittier (12)* have been tested in the uppermost Miocene only. A recent test in the Whittier field penetrated a considerable section of Upper Miocene below present production with unfavorable results. Permeabilities were low as is often the case in the Upper Miocene in the Los Angeles Basin.

Turnbull (13). One well in this small field was drilled considerably below present production with unfavorable results. Because of the small extent of the field it cannot be considered as having important deeper possibilities, although considerable Miocene section and possibly Eocene may be present below the field.

Montebello (14). A test of deeper prospective zones is now being drilled. Union Oil Company's Howard and Smith No. 3. Low permeabilities have so far been reported in new sands uncovered. A thick section of Miocene and possibly Eocene may be expected underlying this field. Structural conditions are favorable for a deep test.

Los Angeles (15). Production in this field has been at shallow depths. A proposed joint test of deeper possibilities may soon be drilled in this field if permits can be obtained from the City of Los Angeles.

Salt Lake (16). A deep test was drilled last year in this field by Shell Oil Company. The Upper and Middle Miocene sections may have been completely penetrated in this well. Structural conditions are complicated and obscure and there may be some question whether the test was drilled in the best structural location. Surface improvements are such that it is unlikely that a suitable deep test will be drilled again in this field.

Beverly Hills (17). Deeper untested possibilities exist in this field. Several attempts have been made to obtain zoning variance from the City of Los Angeles to drill a deep test, but so far without success.

(Continued on Page 112)

LOS ANGELES BASIN

GEOLOGIC SECTION			SEE MAP No. 1	1 CHINO	2 KRAEMER	3 RICHFIELD	4 YORBA LINDA	5 BREA-OLINDA	6 EAST COYOTE	7 WEST COYOTE	8 BUENA PARK	9 SANTA FE SPRINGS	10 PUENTE	11 WHITTIER	12 NO WHITTIER HEIGHTS	13 TURNBULL	14 MONTEBELLO	15 LOS ANGELES	16 SALT LAKE	17 BEVERLY HILLS	18 INGLEWOOD	19 POTRERO	20 VENICE - DEL REY	21 EL SEGUNDO	22 LAWNDALE	23 ROSECRANS-ATHENS	23A WESTERN AVE.	24 DOMINGUEZ	25 TORRANCE	26 WILMINGTON	27 LONG BEACH	28 SEAL BEACH	29 HUNTINGTON BEACH	30 NEWPORT
RECENT PLEISTOCENE						⊤	⊤			⊤	⊤	⊤				⊤			⊤	⊤	⊤	⊤	⊤		⊤	⊤	⊤	⊤	⊤	⊤	⊤	⊤	⊤
PLIOCENE		UPPER PICO			⊤																			○										
		MIDDLE PICO															⊤				●	●												
		LOWER PICO					●														●										●			
		REPETTO					●	⊥	●	⊥	●	●	●	●	⊥			●			●	●	●	●			●			●	●	●	●	●	●
MIOCENE		DELMONTIAN		⊤		●		⊥	●	●			⊥	●	⊤	●		●	⊤		●	●				●	⊥	●	●	●	●	⊥	●	●
		UPPER MOHNIAN STAGE		●	●	●		⊥	●	●	●	⊥				⊥	●	⊥	●	⊤														
		LOWER MOHNIAN STAGE																				●		●	●	⊥								
		LUISIAN AND RELIZIAN STAGES											●						⊥			●											⊥		
		SAUCESIAN AND ZEMORRIAN STAGES		⊥	⊥	⊥				⊥																								
EOCENE												⊥																						
JURASSIC		FRANCISCAN															⊥					⊥												
				3867	4500	10480	5778	8201	9500	9285	10044	11314	9827	8033	1285	8600	10690	1735	7824	6870	12276	9386	6800	8008	7408	10388	9109	12170	6597	6761	10324	9084	9048	3338

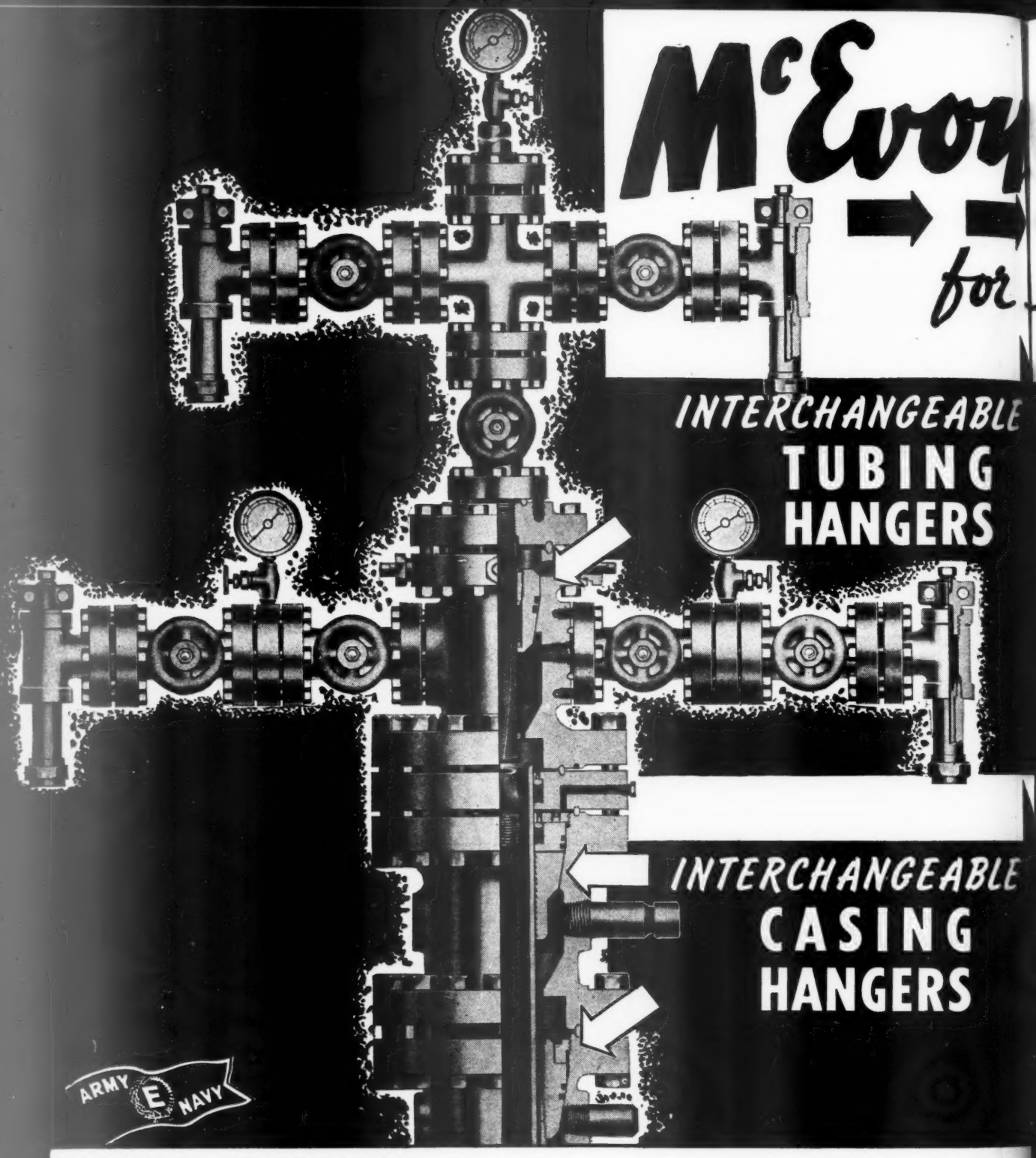
— LEGEND —

⊤ Surface Formation
○ Gas
● Oil
⊗ Abandoned Oil Field
⊘ " Gas "
⊥ Deepest Formation Penetrated

PAW District 5 July 15, 1944

McEvoy

for



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HANGERS

INTERCHANGEABLE
CASING
HANGERS

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McEVOY STANDARDS *Assure*

Complete Safety—Trouble-Free Installation—Complete Flexibility

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Proper heat-treatment is accorded all McEvoy equipment where this treatment will add to the safety of the equipment. Heat treating assures A. P. I. recommended tensile strengths and safety factors even with the National Emergency steels which all manufacturers are now using. Close control of castings is maintained through the medium of X-Ray. There are no hidden flaws in McEvoy well head equipment.

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The McEvoy plant contains machine tools which are among the finest in the world. These tools are turning out a steadily increasing flow of McEvoy equipment for use in oil fields everywhere. They permit us to guarantee you prompt delivery of the right equipment for your job.

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Every piece of McEvoy equipment is individually inspected to meet the close tolerances and specifications set forth by McEvoy engineers. This inspection includes Rockwell and Brinnell tests for proper tensile strength; gaging for proper sizes; chemical tests for proper metal compositions and Durometer tests for correct rubber hardness. These inspections guarantee McEvoy equipment to be correct as specified.

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Each McEvoy well head assembly is subjected to thorough pressure tests before the assembly is shipped. These pressure tests correspond in all instances to A. P. I. specifications and are conducted under the procedure as set forth by the Association of Well Head Manufacturers.

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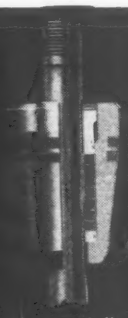
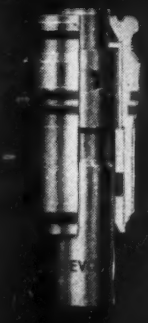
ALB

Threaded mandrel hanger for use where completion methods do not require a specialized hanger.



AFB

Developed especially for dual completions or where production packers are set. Permits well to be washed in under full pressure control without necessity of blow out preventers or back pressure valves. Polished joint allows movement of tubing under pressure



ATSJ

For screen and liner packer settings. Permits tubing to be raised one joint for final suspension after washing screen and setting packer.

ATSC

Permits running and landing of tubing through assembled christmas tree. This hanger is designed to permit any method of well completion.

LHCS-1

Affords a non-welded seal for utmost safety. Slips may be locked together and landed through preventers if desired. This hanger is highly desirable where N-80 pipe is being set, due to difficulty of obtaining a satisfactory weld on this class of pipe.

LHCH

Threaded mandrel hanger permits landing of casing through preventers and is satisfactory where close spacing of pipe is not necessary.

LSE

The Type LSE Flange may be used above any McEvoy Casing Hanger as an auxiliary seal. This flange permits field testing of both upper and lower seals and means are also provided so that both seals may be repacked under pressure

LHCLWS

The LHCLWS Casing Hanger utilizes slips for suspension and welded seal. Slips are assembled inside housing and complete assembly may be landed through blow out preventers.

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(Continued from Page 109)

Potrero (19). Structural conditions are obscure in this field, which complicates prospecting for deeper zones.

Rosecrans-Athens (23). Deeper prospects are less promising in view of the negative results in the deep test of the adjoining Dominguez (24) field. Rapid lateral changes of permeabilities are common in the Miocene, however, so the failure of the Dominguez test does not condemn deeper prospects here.

Long Beach (27). Until the entire sedimentary section has been penetrated in this field, prospects for deeper possibilities are present. A recent deep test north of the main longitudinal Cherry Hill fault proved very disappointing because of low permeabilities. Higher permeabilities of Miocene sands in the Seal Beach field (28) to the southeast suggest that in the southeasterly end of the Long Beach field production may be obtained from the deeper sands, which were found to be too low in permeability to produce commercially in the northwestern part of the field. This idea will be tested by a well now drilling. Whether Eocene sediments may be found under this field is unknown.

Seal Beach (28). Basement has not been reached in this field and consequently it must be considered to have possibilities for deeper Miocene and possibly Eocene production. One or more deep tests are now under way.

Huntington Beach (29). A deep test is now under consideration in this field. Due to a variety of structural features within the field, several deep tests at different locations will be required to evaluate fully deeper possibilities. A recent deep test of the Surf area, shown on the index map to the southeast of the main field, proved unsuccessful. Structural conditions at depth may not have been favorable for accumulation or low permeabilities may have been the reason for the failure of this test, which was not carried to basement as far as we know.

▸ **San Joaquin Valley (East Side).** In most of the fields in this group, wells have penetrated the principal objective sand (Vedder-Miocene), and with few exceptions the basement has been reached.

Premier (35), Kern Front (36), and *Kern River (37).* In these fields there is a possibility that Eocene sands may be present, and, if so, they may well be productive.

Kern Bluff (46). This recently discovered field is producing from the Kern River series. Little is known so far about structural conditions in the field and deeper possibilities are therefore unknown.

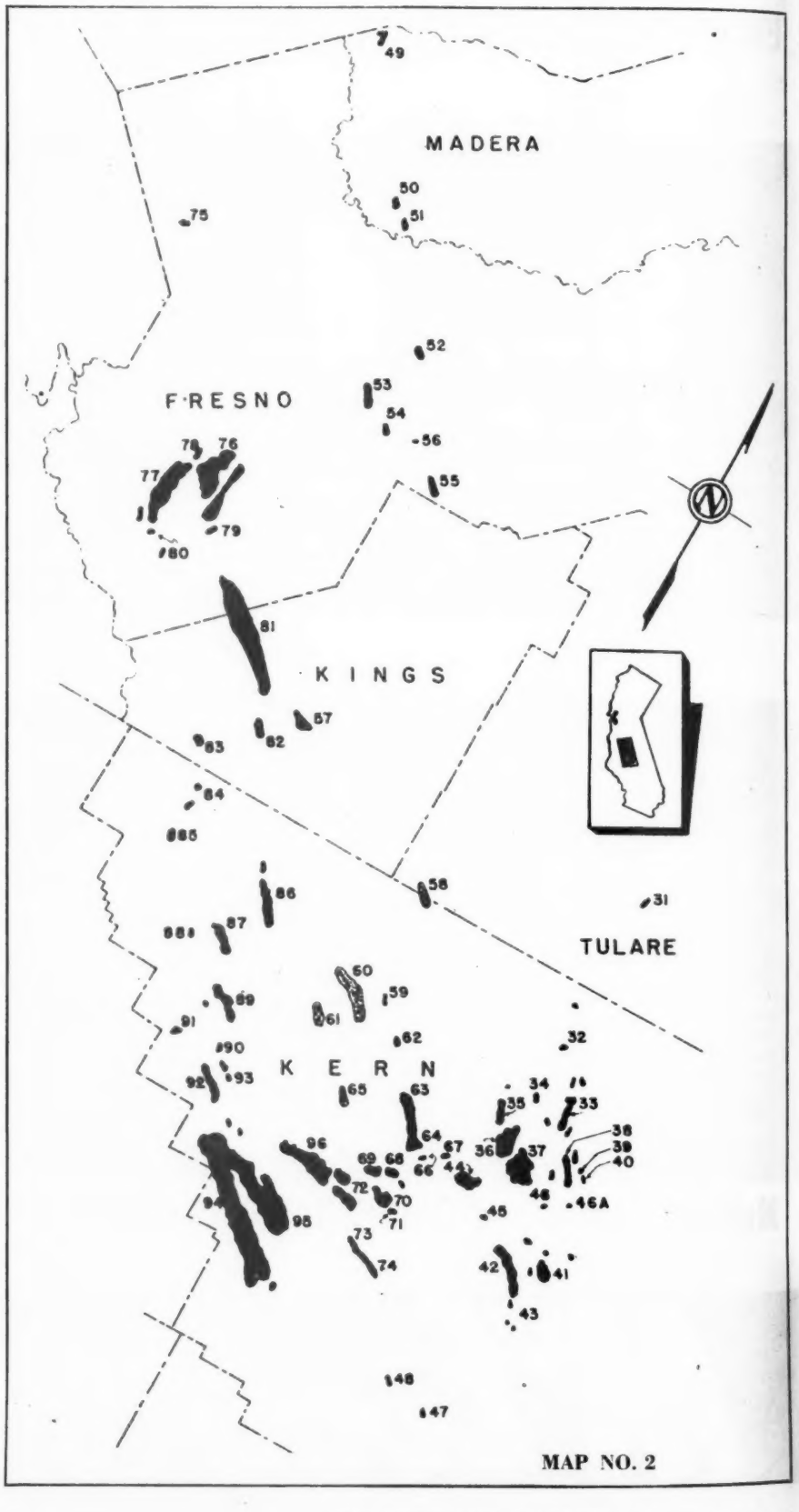
▸ **San Joaquin Valley (Valley Floor).** *Raisin City (52)* and *Riverdale (55).* In view of the absence of oil or gas in the top of the Cretaceous in the wells that reached it, the deeper Cretaceous prospects do not look very promising.

Helm (53) and *Lanare (54)* may have deeper possibilities in the Cretaceous. No deep test has been carried much below the top of the Cretaceous in these fields, at what appeared to be the most favorable location.

Trico (58). One deep test was drilled to a depth of 11,466 ft. just outside the northeast limits of the productive area of this field. The well bottomed in Upper Eocene (Markley). The location was chosen east of the apex of the shallow structure because seismograph work indicated a shift of the axis in that direction at depth. For this reason it does not seem likely that a deep test within the limits of the field would be justified.

Wasco (59). The discovery well in this field was carried into the Eocene, but was plugged back to the present production of Lower Miocene age. Showings of oil were reported from the underlying Oligocene and Eocene to bottom of the hole.

Semitropic (60). Geophysical work has indicated a shift to the east of the apex of this structure at depth. A well is at present being drilled to test the



MAP NO. 2

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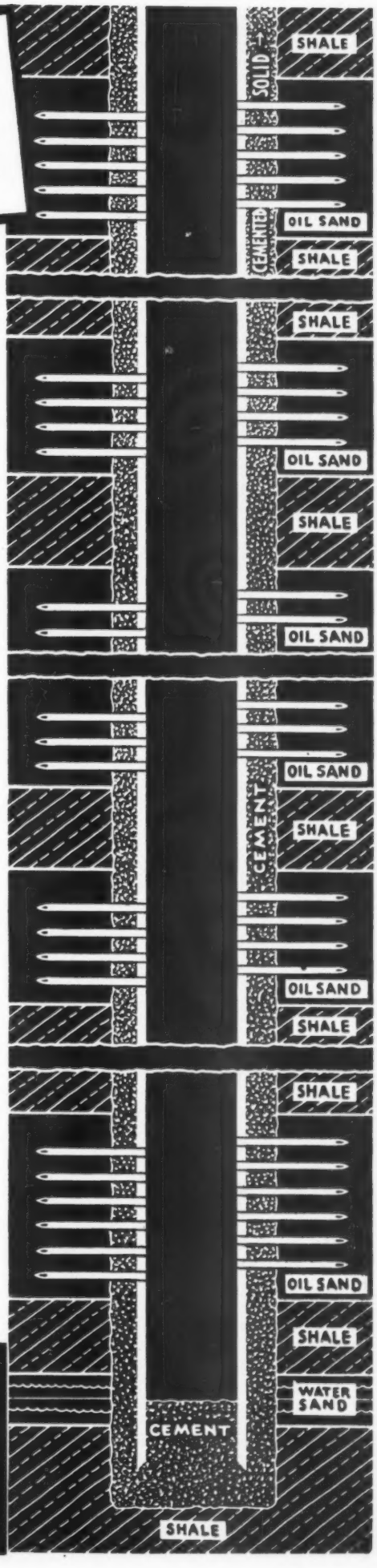

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GEO. WEST, TEXAS	NEW IBERIA, LA.	LAUREL, MISSISSIPPI	AVENAL, CALIF.
ODESSA, TEXAS	SHREVEPORT, LA.		SACRAMENTO, CALIF.

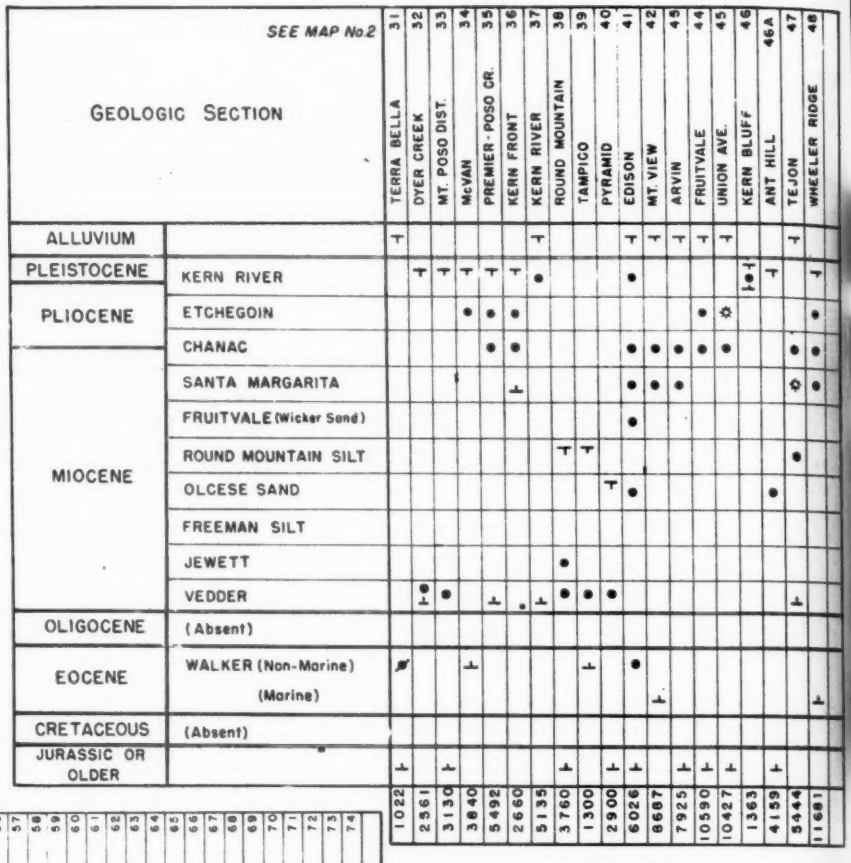
deeper possibilities outside the present producing area on this theory.

Buttonwillow (61). No deep test has been drilled within the limits of this field below the San Joaquin clays (Pleistocene-Pliocene). Deep tests on the Bowerbank structure to the southeast were not encouraging so far as the Buttonwillow deep prospects are concerned. However, the structure may warrant a deep test. Prospective zones would be very deep with the Vedder-Rio Bravo sand probably at 15,000 ft.

Shafter (62). The possibility that Eocene sands may be productive in this area will eventually justify a deeper test. The structure is small, and untested zones would be below 13,000 ft.

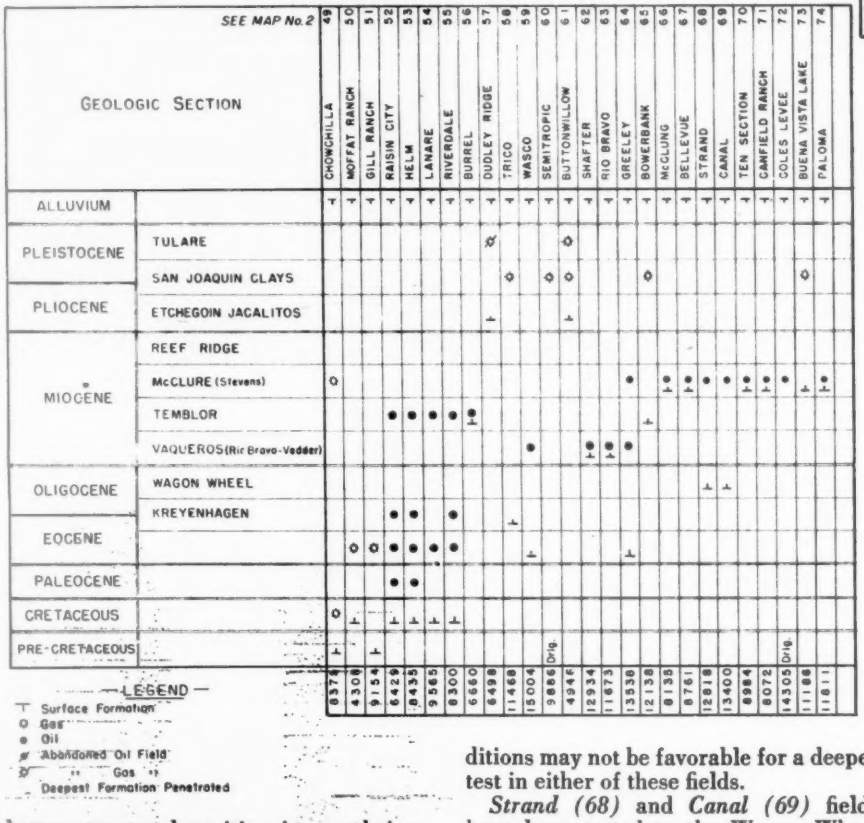
Rio Bravo (63). No test has been carried to the Eocene within the field, and prospects appear fair enough to warrant deeper drilling. Untested zones lie below depths of 11,500 ft.

Greeley (64). One well on the edge of the field, Elrich Community No. 1, was drilled to basement at a depth of 13,538 ft. This well encountered about 40 ft. of gray Eocene sand. The possibility that this sand may prove productive at a



SAN JOAQUIN VALLEY—East Side.

SAN JOAQUIN VALLEY—Valley Floor.



better structural position is now being tested near the top of the structure.

Bowerbank (65). A deep test has been drilled to the Temblor in this field within the area of shallow gas production. Closure at depth is reported questionable on the basis of geophysical data, and a deep test for Vedder sands does not appear very attractive.

McClung (66) and *Bellevue (67)* have not been tested much below present Stevens sand production. Structural conditions may not be favorable for a deeper test in either of these fields.

Strand (68) and *Canal (69)* fields have been tested to the Wagon Wheel (Oligocene) with no production below the Stevens zone. The Vedder sand was reported to be very low in permeability. Eocene possibilities may exist under both of these fields at depths of more than 13,500 ft.

Ten Section (70). Because of the size of this structure, the untested Vedder and Eocene sands present very attractive deeper zone prospects and lie within currently feasible drilling depths.

Coles Levee (72). A deep test is at present drilling on this structure. The well will probably be carried to the Vedder. Eocene prospects should also be present under this field.

Buena Vista Lake (73), Paloma (74). Deeper drilling in this field should be of interest since only the equivalent of the Stevens zone has thus far been tested. Because of faulting, thinning, and lateral changes in facies in the Paloma field, the best location for a deep test may not be at the apex of the structure. A deep test to explore new formation would have to be drilled to depths in excess of 10,500 ft. The Vedder sand, or its equivalent, may lie at a depth of more than 13,500 ft., and the Eocene may not be reached above a depth of 15,000 ft.

▶ **San Joaquin Valley (West Side).** Recent discovery of Eocene production in the *Antelope field (88)* has enhanced the deeper prospects for Eocene production in other fields on the west side of the San Joaquin Valley. Previously the most southerly Eocene production was obtained from the Kettleman North Dome field (81) about 40 miles to the north.

Kettleman North Dome (81). The possibility for deeper production in this field exists until the entire sedimentary section has been penetrated. The deepest production now comes from Avenal sand of Eocene age. The entire Eocene section has not been penetrated, and its thickness is not known. Cretaceous beds should be found underlying the structure, which, because of its size, should

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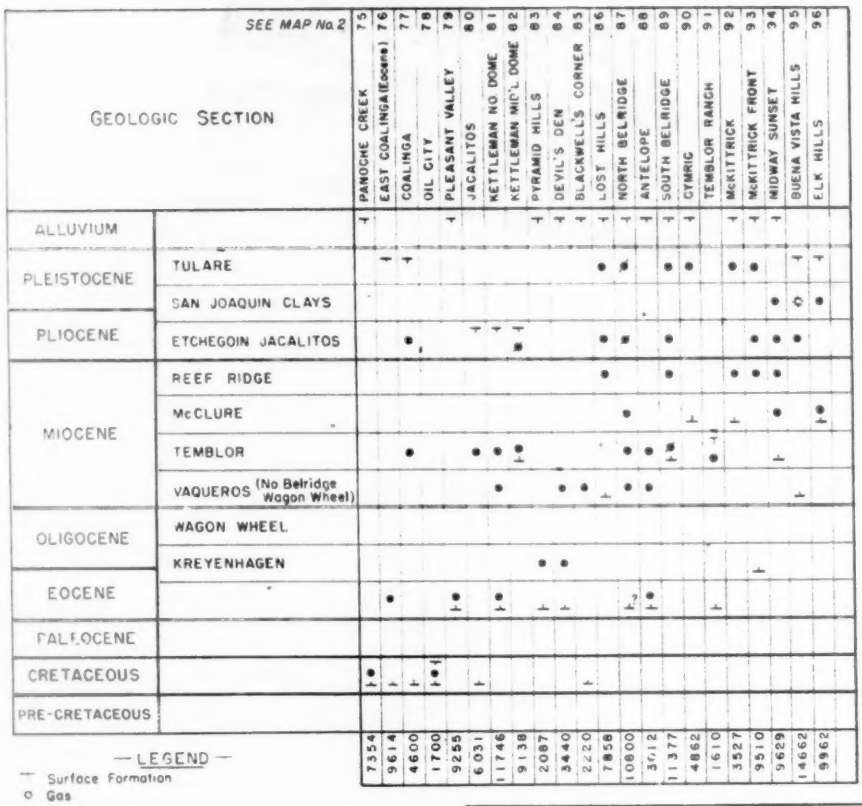


SAN JOAQUIN VALLEY—West Side.

be one of the most attractive places to test possibilities of the Cretaceous in the San Joaquin Valley.

Kettleman Middle Dome (82). Should Lower Eocene and Cretaceous prove productive at North Dome, this field appears favorable for a deep test of the Eocene and Cretaceous possibilities.

Lost Hills (86). The deep possibilities of this large structure are promising in the Eocene. A deep test is now under way in the southeastern end of the field, which is located to test the possibility of accumulation in sands older than any so far penetrated The location is made on the southeast plunge of the structure with the idea that overlapped Eocene sands may be present.

North Belridge (87). Deeper prospects still exist in this field in the Eocene and possibly in the Cretaceous.

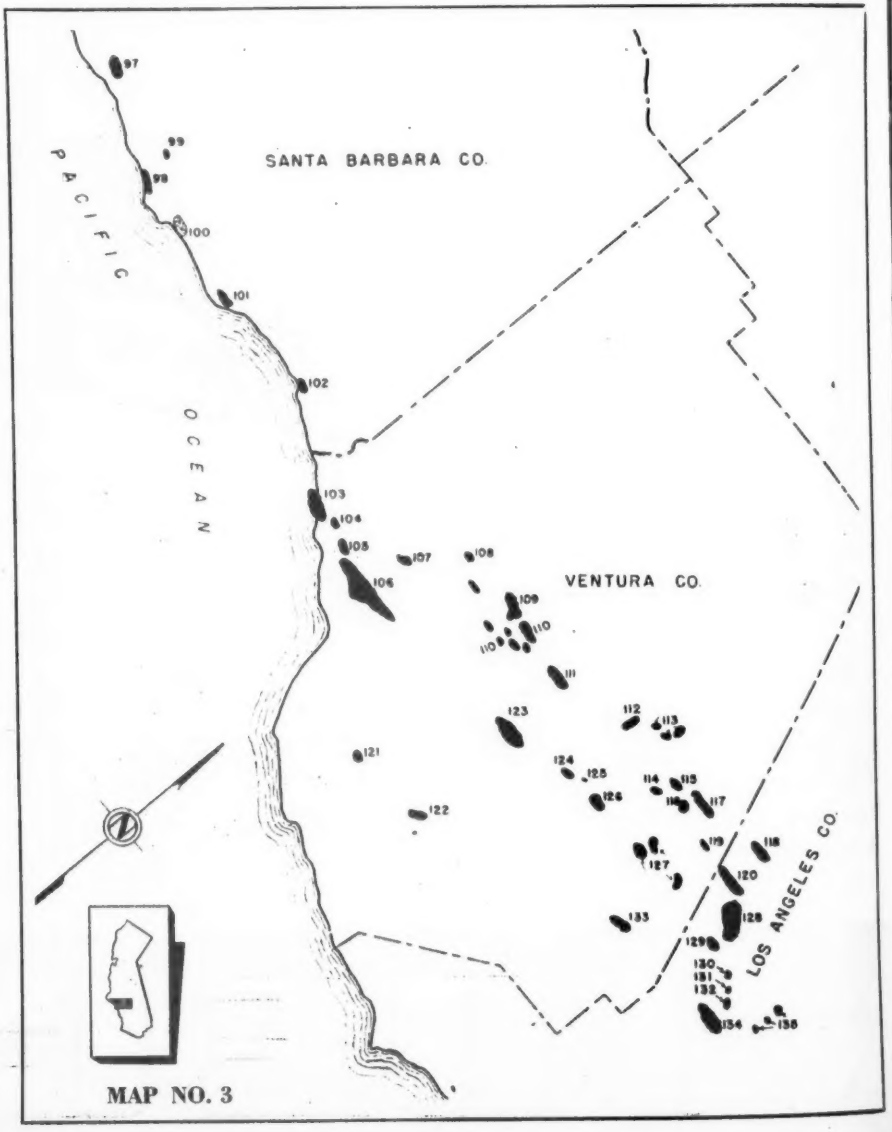
Antelope (88). Structural conditions in this field do not favor deeper accumulation within the productive limits. Rapid lateral changes in facies, overlap conditions, and faulting offer possibilities for production in the vicinity of the present productive area in beds older than those presently producing in the field. Discovery of Eocene production from a wildcat to the north of the field improves the prospects for Eocene production on the west side of the San Joaquin Valley south of Kettleman Hills.

South Belridge (89). The structural conditions at depth in this field are not well known. Deeper possibilities below the McLure (Upper Miocene) are probably present. One deep test found good showings in the Temblor below 11,000 ft., but was abandoned largely for mechanical reasons.

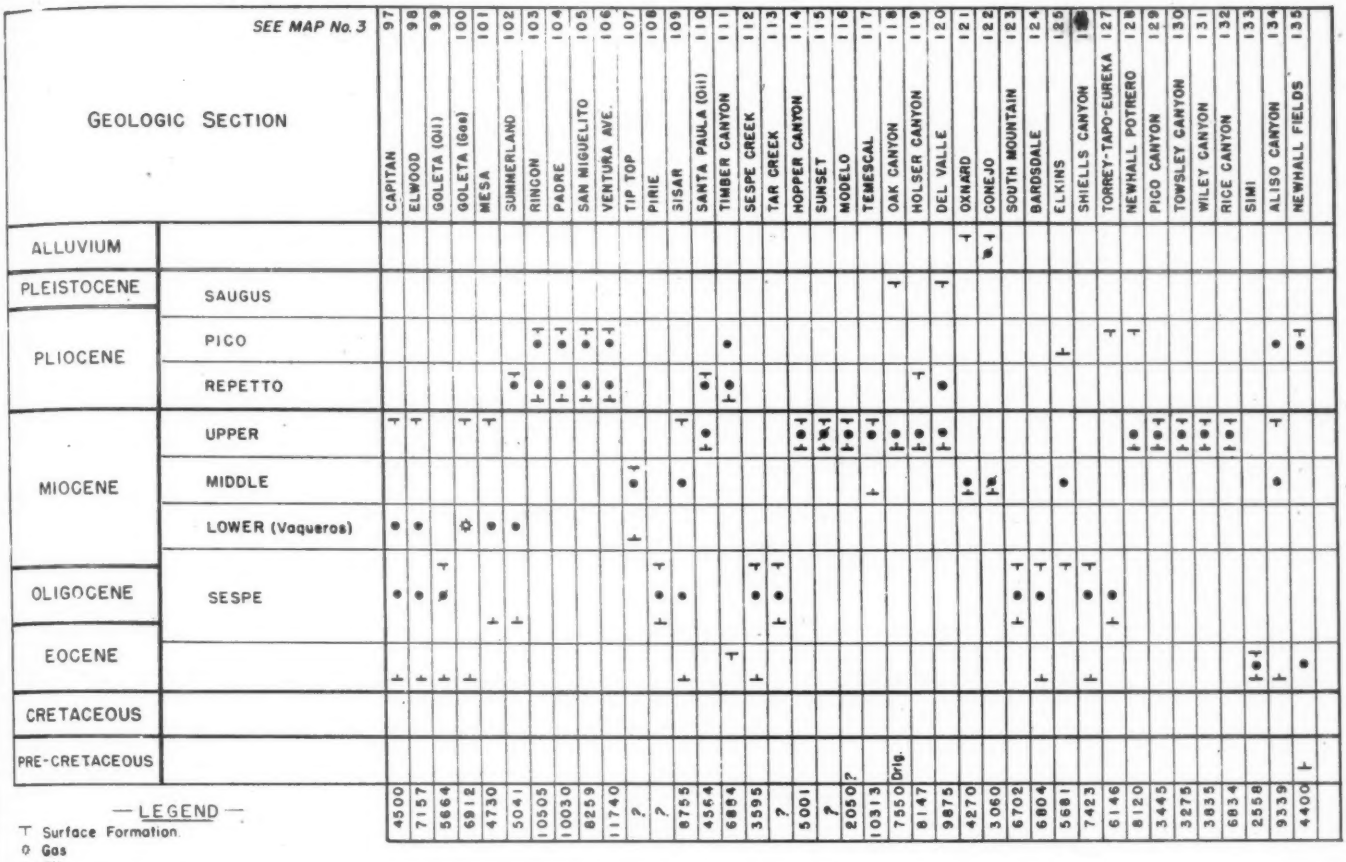
McKittrick Front (93). A deep test was drilled recently into the Oligocene in this field. Present production comes from sands of Pliocene age. Deeper prospects above the Eocene appear to have been condemned.

Midway Sunset (94). Due to the structural and stratigraphic complexity and large areal extent of this field, it is very likely that deeper possibilities exist. Many local areas remain untested in deeper zones known to be productive in other parts of the field. The United States Geological Survey is at present making a detailed study of such possibilities the results of which should reveal some favorable areas for deeper zone tests. One deep test is now being drilled in Section 36-12N-24W to test for zones below any now producing in the field.

Buena Vista Hills (95). The recent discovery by Standard Oil Company of the 27-B sand indicates the possibility for deeper production in local areas within this extensive field. One deep well drilled by Honolulu Oil Company in the southeastern part of the field was



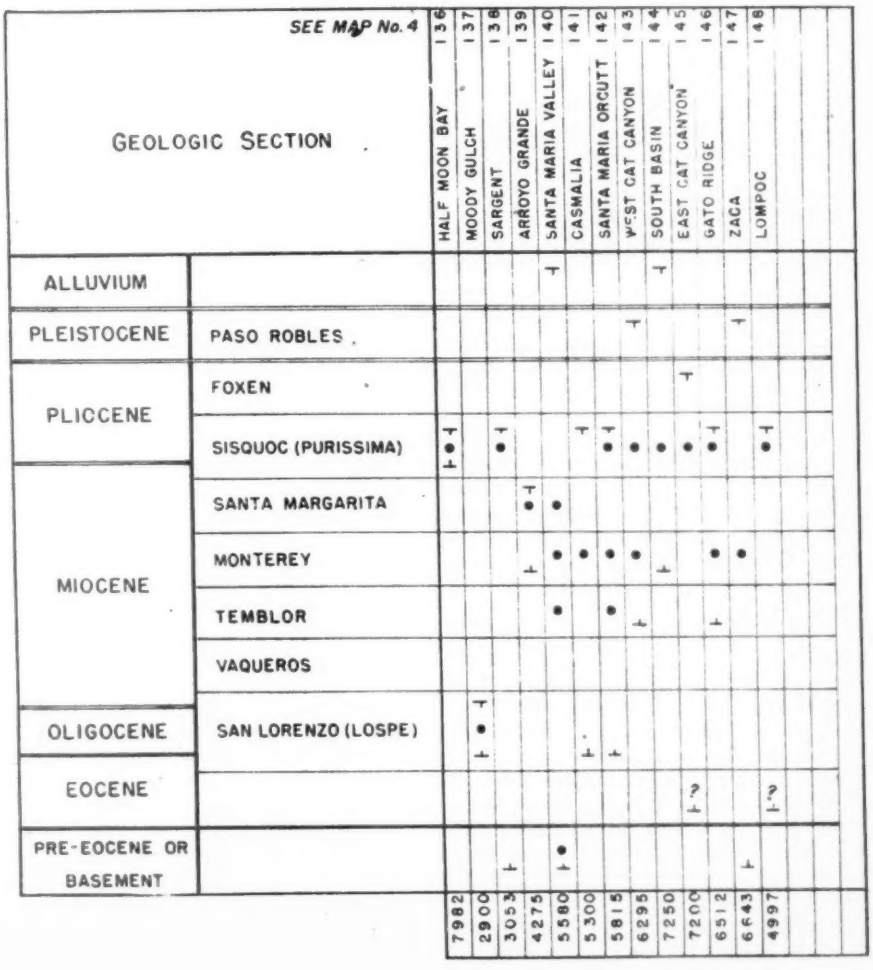
MAP NO. 3



— LEGEND —

⊤ Surface Formation.
○ Gas
● Oil
⊀ Abandoned Oil Field.
⊀ " Gas "
⊥ Deepest Formation Penetrated.

Above—VENTURA BASIN. *Below*—SANTA MARIA BASIN AND MISCELLANEOUS COASTAL DISTRICTS

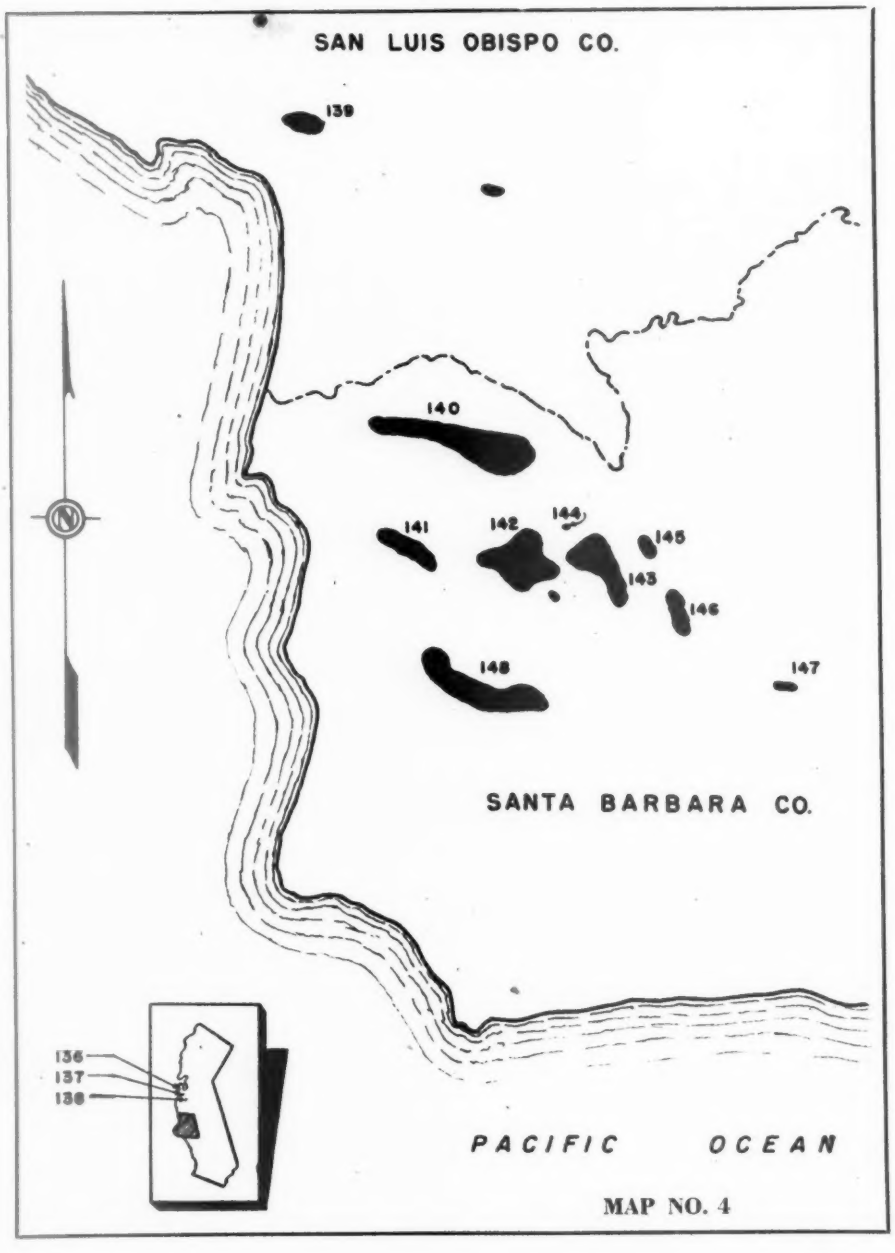


discouraging with respect to Miocene possibilities in that part of the field. Stratigraphic variations may complicate the picture. A recent well drilled outside the field on the northeast flank of the structure by the Union Oil Company (well U. S. No. 1-B in Section 20-31-24) encountered no permeable sand in the Miocene to a total depth of 9542 ft., at which point the well was approximately 1000 ft., below the top of the Miocene. Eocene prospects under this large structure should be given some consideration.

Elk Hills (96). Lower and Middle Miocene and Eocene possibilities may exist in this field. Because of the size of the structure these may be very important.

Ventura Basin. In the Ventura Basin one of the most promising untested possibilities is that of accumulation below the major thrust faults (San Cayetano and Oakridge) bordering the Santa Clara River Valley. Although such accumulation will in general follow the trend of the present producing fields located above the thrust faults, it will be coincidental if they should underlie present production. For this reason they cannot be considered deeper zone prospects in the ordinary sense, and in most cases the age of prospective zones although at greater depth will be younger than those presently producing.

Capitan (97) and *Elwood (98).* Although wells have been drilled into the Eocene in both of these fields without finding any production, the possibilities of the thick Eocene section that must un-



MAP NO. 4

derlie these fields cannot be considered as having been adequately tested.

Rincon, (103), Padre (104), San Miguelito (105), and *Ventura Avenue (106).* In none of the fields has the entire Repetto (Pliocene) section been penetrated. Deeper possibilities in the Pliocene are therefore present. Production can also be expected in the underlying Miocene, which produces in the Ventura Basin both east and west of these four fields. Similarly, possibilities in Sespe (Oligocene) and Eocene beds may also be present. Although drilling to these formations will be deep, they appear to present some of the most promising deeper prospects in California at the present time.

Oak Canyon (118), Holser Canyon (119), and *Del Valle (120).* These three fields have not been tested below the Upper Miocene. Prospects for deeper production from older Miocene beds and particularly from the Eocene, which produces to the south, Simi (113), and east Newhall fields (135) are a possibility in these three fields. A deep test is now in progress in the Oak Canyon Field.

Oxnard (120). Because of structural conditions in this field, it is most likely that deeper production (stratigraphically) here will be outside the present producing area which is very small owing to the limited development in the field.

South Mountain (123), Bardsdale (124), Elkins (125), and Shiells Canyon (126). These fields probably have some further deep possibilities above the Oakridge thrust fault. There are very promising prospects for accumulation underneath the major thrust that passes below the four fields. Accumulation below the fault will probably not be affected by structural conditions above the fault. For this reason the deeper possibilities under these fields must be considered far more hazardous than is normally the case in deeper zone prospecting under a known field.

Newhall Potrero (128). This field should have excellent deeper zone prospects for Miocene, Oligocene, and Eocene production. A deep test is now in progress.

Pico Canyan (129), Towsley Canyon (130), Wiley Canyon (131), and *Rice Canyon (132).* These four fields have deeper prospects in the equivalent of the Sesnon zone producing in the Aliso Canyon (134) to the south as well as from the Eocene producing in Newhall (135) to the northeast and Simi (133) to the southwest. A deep test is planned for Pico Canyon.

Aliso Canyon (134). Several wells have been drilled to the Eocene in this field without success. Further information about structural conditions may eventually reveal a better location for a test of the Eocene.

▸ **Santa Maria Basin.** Deeper possibilities in the Santa Maria Basin fields are largely prospects for accumulation in permeable rocks below the Monterey (Upper Miocene) where the oil from Miocene shales had a chance to migrate into such older rocks. One such type of accumulation would be similar to the schist and shist conglomerate accumulation in the Venice (20) and El Segundo (21) in the Los Angeles Basin.

As this type of accumulation does not necessarily follow the pattern of upper zones, it appears that several deeper tests would have to be drilled in order to test adequately this type of accumulation in each field. The following fields may have possibilities of this type: *Santa Maria Valley (140), Casmalia (141), Santa Maria-Orcutt (142), West Cat Canyon (143), East Cat Canyon (145), Gato Ridge (146),* and *Lompoc (148).*

▸ **Northern district fields.** *Tompkins Hill (149).* This field, which presently produces wet gas from beds of the Middle Pico (Pliocene) age, should have good prospects for oil production from older Pliocene and possibly from Miocene sediments that may be present under the field.

Rio Vista (160). In this gas field, which is by far the largest in the state, the entire Eocene section has not been penetrated so far. Because of the presence of gas in beds of Upper Cretaceous age in fields to the north and south, there is good reason to anticipate Cretaceous gas production. In view of the large size of the structure this appears to be the most important prospect for adding substantially to the gas reserves of the state by deeper drilling within known fields.

Most of the gas fields of the northern district have penetrated and tested beds of Upper Cretaceous age. In some of these fields, only the uppermost sands in the Cretaceous have been productive. Until further drilling of deeper Cretaceous sands has been undertaken, most of the fields with appreciable anticlinal closure may be considered to have deeper possibilities.

▸ **Conclusions.** The history of California oil development shows the importance of deeper zone discoveries not only in adding to our reserves, but also in increasing current production rates.

Results of some of these deeper zone discoveries have far exceeded the most

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optimistic estimates made at the time of the original field discovery. Santa Fe Springs, Rosecrans, North Belridge, Sunset Midway, and Ventura Avenue are just a few examples of fields in which such has been the case.

The continued development of deeper zones created a challenge to the industry for improvements in drilling technique and equipment, which the industry has met admirably to date. These improvements have made possible still deeper exploration until today we speak of 15,000-ft. tests without batting an eyelash.

Until the full stratigraphic section has been penetrated in all California oil and gas fields, we may expect this development to continue, and, as a result, new reserves will be added to our supply.

It is hoped that this paper will call attention now to some of the remaining undrilled, deeper-zone prospects at a time when increased production and available reserves are urgently needed to carry on the war.

▶ **Supplement.** Revisions of data due to operations from July 15 to September 1, 1944, are summarized below. Key numbers following the names of fields refer to similar key numbers on the charts.

Buena Park (8). The outpost of this field was drilled to 11,422 ft. and plugged back to 11,200 ft. to test reported oil sands.

North Whittier Heights (12). A second well drilled to 1900 ft. and plugged back to 1600 ft. found oil in a sand 400 ft. below the previously discovered producing zone.

Montebello (14). A second deep test is drilling in this field. However, it is within the old area of Pliocene shallow production.

Inglewood (18). A deep test below the Sentous is believed to have been unsuccessful in discovering a new deep zone.

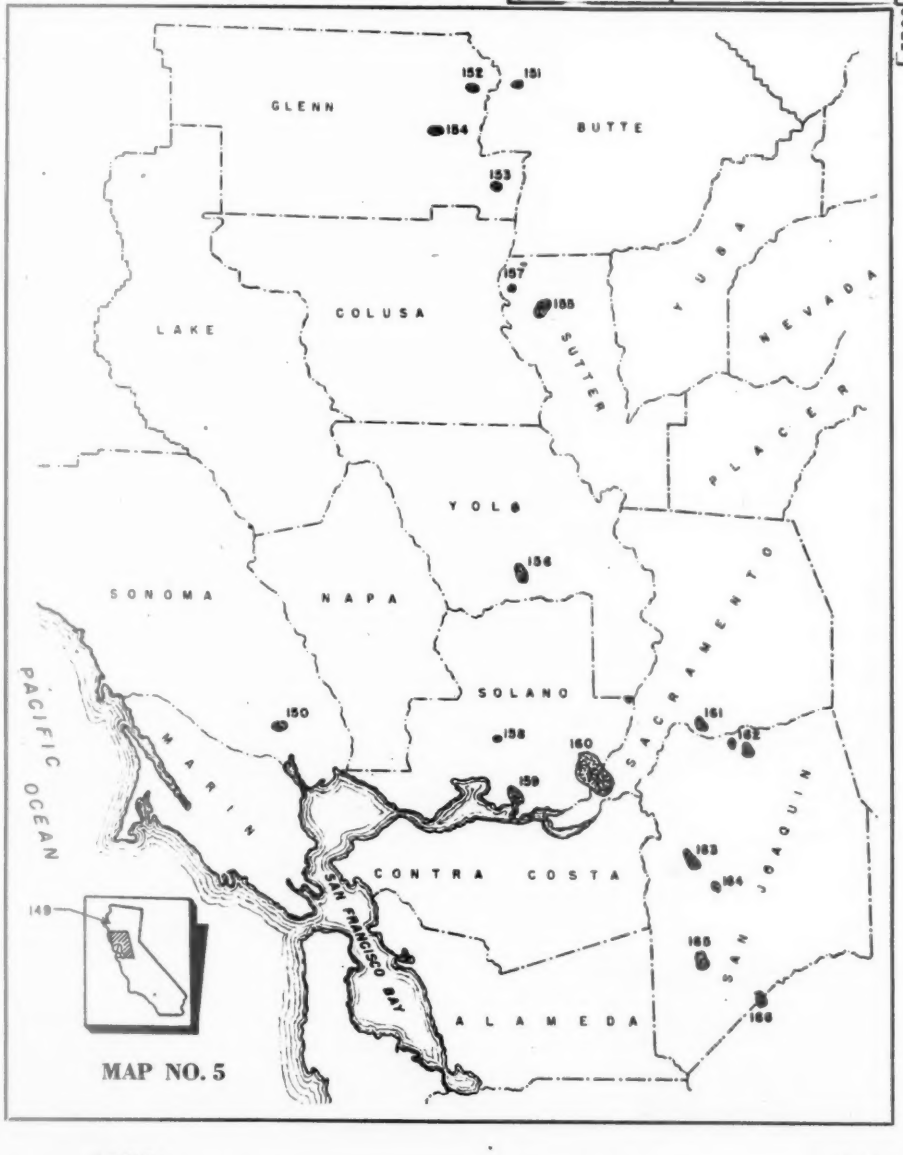
Wilmington (26). A number of wells have been drilled, and others planned, to test the basement weathered zone below the Ford zone.

Semitropic (60). The deep test of this field had reached 11,987 ft. by September 1.

Greeley (64). The deep test reached basement at 13,465 ft., but testing of the Eocene had not been completed.

Coles Levee (72). The deep test of this field, down 14,845 ft., was approaching the California deep hole record of 15,003 ft., with results not reported.

Midway-Sunset (94). The deep test in section 36-12n-24w was abandoned at 8647 ft., probably still in Middle Miocene beds. ★ ★ ★



MAP NO. 5

GEOLOGIC SECTION		SEE MAP No. 5	149	150	151	152	153	154	155	156	157	158	159	160	161	162	163	164	165	166
			TOMPKINS HILL	PETALUMA	CHICO	ORD BEND	AFTON	WILLOWS	MARYSVILLE BUTTES	FAIRFIELD KNOLLS	COLUSA	POTRERO	SUISUN BAY	RIO VISTA	THORNTON	LODI	McDONALD ISLAND	ROBERTS ISLAND	TRACY	VERNALIS
ALLUVIUM					┴	┴	┴	┴			┴		┴	┴	┴	┴	┴	┴	┴	┴
PLEISTOCENE			┴																	
PLIOCENE			☼ ┴	☼ ┴						┴										
MIOCENE									┴											
EOCENE	NORTONVILLE															☼				
	DOMENGINE													☼						
	CAPAY									☼		┴	☼	☼	☼					
	MEGANOS													☼						
PALEOCENE													┴?	☼			☼	☼		
CRETACEOUS	UPPER				☼	☼	☼	☼	☼	┴	☼	┴☼			┴		┴		☼	☼
	LOWER																			
BASEMENT					┴											┴		┴		
			7708	2140	7005	6346	5242	6014	7650	5181	3460	5334	8304	6792	8367	4495	8813	7014	9690	5506	

— LEGEND —

- ┴ Surface Formation.
- ♪ Gas
- ● Oil
- ✱ Abandoned Oil Field.
- ☼ " Gas "
- ┴ Deepest Formation Penetrated.

NORTHERN DISTRICT FIELDS

Manufacturing Processes for High Octane Aviation Gasoline*

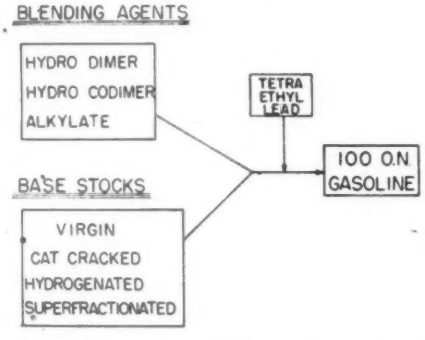
By **E. V. MURPHREE,** *Vice President*
Standard Oil Development Company

THE various hydrocarbon constituents of petroleum probably differ more in the property of anti-knock or suitability for high power aviation engines than they do for any other use. The ultimate measurement of this property must, of course, be carried out on a representative full scale aviation engine.

By present standards virgin gasoline is not a good fuel. Since about 1935 natural petroleum has been chemically converted by ever-improving processes to better products from the standpoint of utilization in aviation engines, and it is my purpose to outline these developments up to the present day, keeping in mind the two dimensions of quality and volume requirements. In the early days of this period the demand for aviation fuel was almost negligible compared to other petroleum products. Even in the spring of 1941 production of 100-octane gasoline was about 26,000 bbl. per day, and this volume represented less than one per cent of every barrel of crude oil run. Presently production of 100-octane number gasoline is 15 or 20 times that volume. The petroleum industry's main concern since the start of the war has been the installation of equipment to satisfy this ever-increasing demand by the utilization of processes developed before the war along with some in the process of development when the war started. Presently the aviation gasoline volume problem has been pretty well worked out, and it was in the anticipation of the arrival of anti-knock quality as the important dimension that the Jersey company made plans for the installation of a full scale aviation test stand about a year and a half ago. The immediate purpose of this test stand is to be able to select better the presently available processes and products for optimum use in military equipment, and the long-time purpose is to modify most effectively available processes and to develop new processes for the production of even superior aviation fuels for war and peace.

100-octane fuel: Definition. By definition 100-octane fuel is any fuel that on a given engine matches in anti-knock quality chemically pure isooctane (2, 2, 4 tri-methyl-pentane, one of 17 possible isooctanes). When the engine comparison is made the test fuel 100-octane may contain lead tetraethyl, but the isooctane reference fuel is used clear. As lead tetraethyl increases the anti-knock quality of any fuel it follows that isooctane plus lead will rate above 100-octane number and that isooctane plus lead can have added to it a certain amount of lower quality fuel (e.g. virgin gasoline) to give a blend rating of 100-octane number. Without the use of lead, production capacity for 100-octane fuel would be only a fraction of what it is, because it would not be possible to follow this blending practice. In order to make this point clear I am going to anticipate a little by referring to Fig. 1,

Fig. 1. Aviation gasoline manufacture.

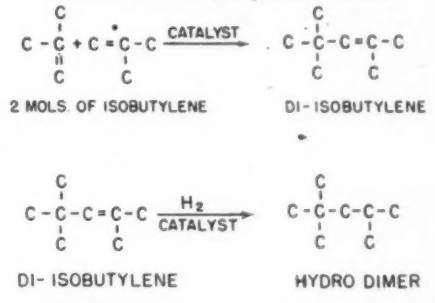


which shows typical blending practice as applied to important blending agents (to be described later), base stocks, and lead tetraethyl. Each increment of lead added permits the use of additional base stock in the blend, thereby increasing the 100-octane production. Also, each increment of lead added to the blending agents (without base stocks) permits the production of better and better "super fuels" rating above 100-octane number. By judicious use of blending procedures it is possible to improve the quality as the volume demand decreases, but it is quite evident that quality and quantity vary inversely.

Aviation blending agents. It is convenient though not wholly accurate to look at 100-octane number gasoline as composed of high quality blending agents and lower quality base stocks (plus lead).

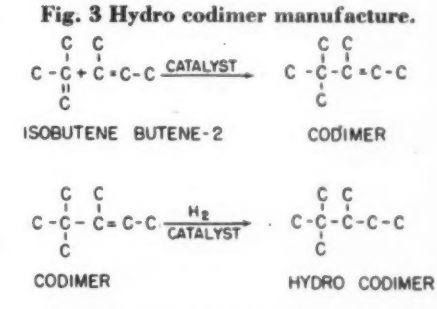
One of the first blending agents used for making commercial 100-octane number aviation fuels was isooctane. Long before that this material was used in the country's testing laboratories as one of the standards of the octane scale, for in 1929 the Jersey group supplied the raw material for the first isooctane shipped for this purpose by the Ethyl Corporation. This raw material is formed from the condensation of two molecules of isobutylene (which is produced in oil cracking operations) and is therefore known as di-isobutylene. When hydrogenated, di-isobutylene becomes isooctane. The Jersey group's first production of essentially pure isooctane, (then known as hydrooctane) for use as a blending agent for the production of 100-octane number gasoline was in 1935. This material was supplied commercially to the Army Air Corps. The manufacture of isooctane, or what we knew commercially as hydro dimer, is shown in Fig. 2. There are two operations involved, polymerization and then hydrogenation of the polymer. The polymerization step was known as the "cold acid" process.

Fig. 2. Hydro dimer manufacture.



That was the process exclusively used from 1935 until early 1938. The supply of refinery isobutylene essential to the first 100-octane was sufficient for only a short period. To increase the supply of suitable raw materials there was developed the so-called "hot acid" process by which the butylene as well as the isobutylene in refinery gas could be polymerized. The polymer so produced was called codimer, which on hydrogenation was converted to mixed isooctanes, called collectively hydrocodimer. The hot acid process with the refinery supply picture then in view, substantially doubled the quantity of synthetic isooctane available. The chemist's way of putting this is shown in Fig. 3. Jersey's production of hot acid polymer began in the early part of 1938. A somewhat similar process using solid catalyst is known as the "Selective Polymerization Process."

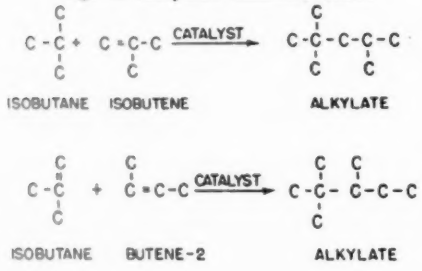
Fig. 3 Hydro codimer manufacture.



Production of high octane blending agents while expanded by the hot acid process was still potentially too limited in scale. Through research carried out by various oil companies a means was found for producing a saturated polymer requiring no hydrogenation through condensation of a saturated C_4 hydrocarbon, known as isobutane, with

*Given at opening of Aviation Fuel Test Unit, Bayway, New Jersey, September 19, 1944.

Fig. 4. Alkylate manufacture.

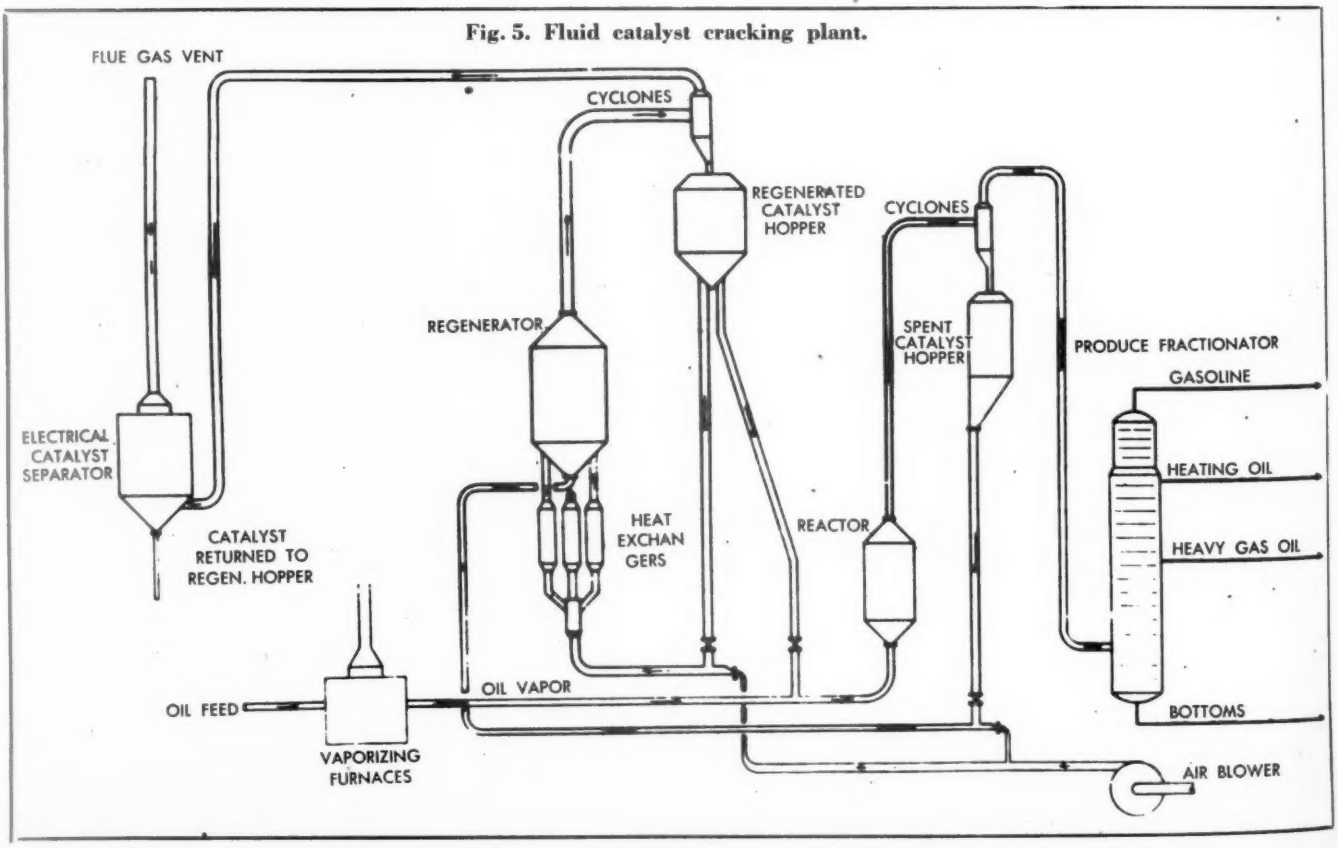


one of the unsaturated C_4 hydrocarbons, generally classed as butylenes. This reaction is shown in Fig. 4. This process is known as alkylation and with sufficient availability of isobutane all butylenes in the refinery C_4 cut can be converted over to high octane number blending agents. This process, therefore, taking into consideration the isobutane condensed with the butylenes, potentially triples the production of high octane blending agents compared with the hot acid process, and makes the potential production six times greater than could be obtained through isooctane process. In addition it has been found that isobutane can be condensed to give high octane number polymers with both olefins of the C_3 fraction of cracked gasoline and also with propylene, which is in the C_3 fraction. The alkylation process today is by far the most important process for production of high octane number blending agents for 100-octane aviation gasoline. Intensive research is now being carried out on improving still further the quality of the alkylate produced through modifications in the process. As a result of research carried out by the Standard Oil Development Company and the Humble Oil and Refining Company, the world's first commercial alkylation plant was put in operation by Humble in the fall of 1938.

▶ **Raw materials for blending agents and base stock production.** The development of the alkylation process gave a very effective means of producing large quantities of 100-octane fuel, provided sufficient butylenes and other unsaturates were available, and provided sufficient isobutane and aviation base stock could be produced. The raw material problem for 100-octane gasoline production has been to a large extent solved through the development of catalytic cracking. This process gives relatively high octane number aviation base stock and at the same time produces relatively large amounts of C_4 hydrocarbons. This is particularly true for the fluid catalytic cracking process where, under proper conditions, high yields of butylenes and isobutane based on oil charged can be obtained in addition to base stocks for extending volume. In order to meet the aviation gasoline requirements, 40 fluid catalyst cracking units are either in operation or under construction. These units will have a total rated charge capacity of about 440,000 bbl. of oil per day. Due to the large production of butylenes, which is a raw material for butadiene, the fluid catalyst cracking units make an important contribution to the rubber program.

The fluid catalyst cracking process represents a new engineering technique for contacting catalyst with vapors or gases and in a broader sense represents a new method of commercially handling solid materials. In this process the catalyst, which is in powdered form is handled in such a way that it flows like a fluid in all stages of the process. A flow sheet of a fluid catalyst cracking unit is shown in Fig. 5. It will be noted that oil either in vaporized or liquid form is contacted with hot catalyst flowing down a standpipe and that this mixture then flows into a reaction vessel where cracking occurs. In the reaction vessel the gas velocity is appreciably slowed down and because of this it is possible to build up relatively high concentrations of catalyst because of the tendency of the catalyst partially to settle out against the up-flowing gas steam. The mixture of catalyst and cracked products passes through powder separating equipment and the recovered catalyst then passes down a standpipe where it joins a stream of air and is blown into the regenerator. This regeneration step is necessary to remove the coke laid down on the catalyst during the cracking reaction which deactivates the catalyst. The action in the regenerator is similar to that of the reactor, in that high catalyst concentrations are built up, and in this vessel the coke is burned from the catalyst by air. The mixture of flue gas and catalyst leaves the regeneration vessel and the catalyst is recovered in suitable dust collecting equipment and passes down through a standpipe to meet again the oil stream, thus completing its cycle. In commercial units the heat liberated in the regeneration vessel will be of the order of 200,000,000 B.t.u.'s per hour. The rate of catalyst circulation in certain commercial units has been as high as 6,000,000 lb. per hour, or 50 tons per

Fig. 5. Fluid catalyst cracking plant.



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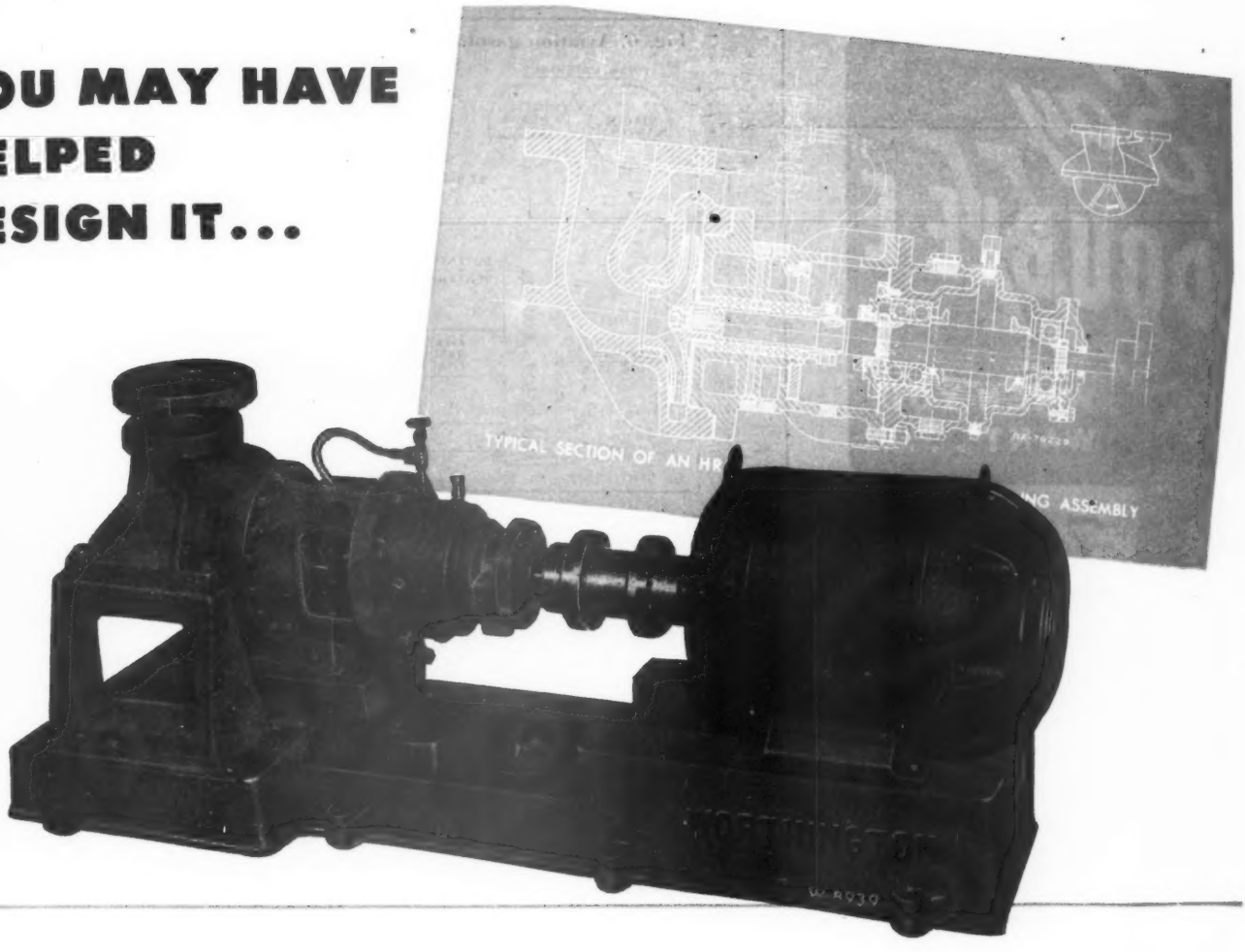

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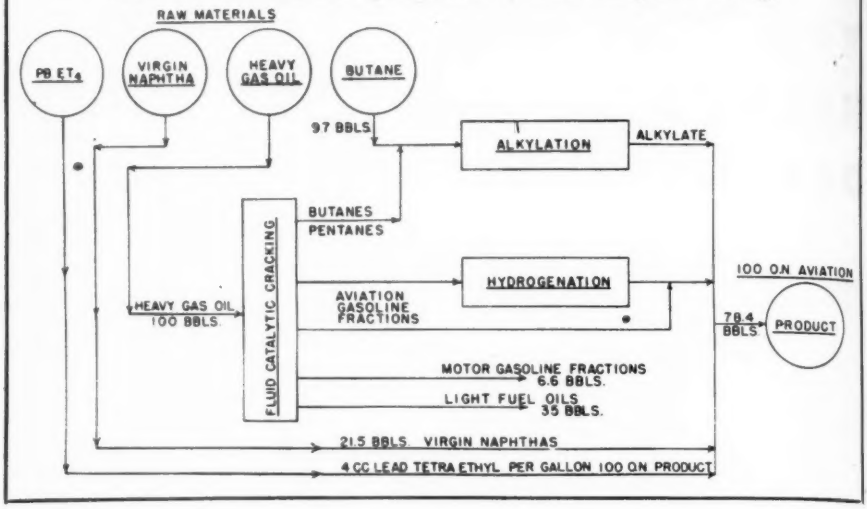
Fig. 6. Aviation gasoline production by fluid catalytic cracking.



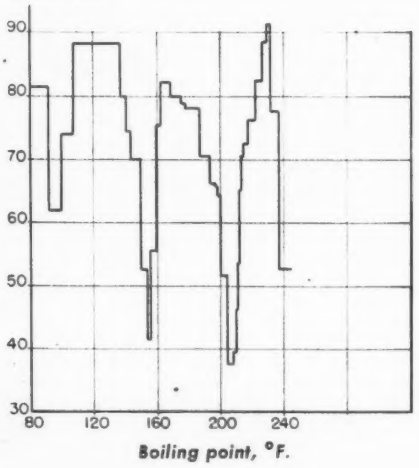
minute. A typical integration of catalytic cracking with other processes for the production of aviation fuel is shown in Fig. 6.

With the greater quantities of butylenes and other low boiling unsaturates made available through catalytic cracking, there developed a need for additional supplies of isobutane. Fortunately, through the effort of various oil companies a process was developed for converting normal butane, which is relatively plentiful, into isobutane by a process known as isomerization. This is the simplest type of chemical change possible and is shown in Fig. 7. One of the companies in the Jersey group put into operation the first commercial isomerization plant. Isomerization is now being practiced on a large scale for production of isobutane for use in making high octane blending agents for 100-octane fuel.

▶ **Supporting processes.** One interesting development in increasing production of 100-octane fuel has been the use

Fig. 7. Butane isomerization.

Fig. 8. Anti-knock distribution of a virgin naphtha.



of very precise fractionation of virgin naphthas to segregate out the high octane number components that are used as base stock. By this process it has been possible to make substantial improvements in the quality of virgin base stock. Fig. 8 shows a typical distribution of the octane number of narrow cut fractions making up virgin naphtha as a function of boiling range. In super-fractionation the low octane number materials are removed, leaving behind those of high octane number.

Hydroforming, which is a process largely developed by the Jersey group, is of primary importance for production of synthetic toluene. This process normally involves treatment of virgin naphthas to produce aromatics. Aromatics, other than toluene, are obtained in this process and these other aromatics have been useful in extending supplies of 100-octane fuel.

The hydrogenation process has been of considerable importance throughout the period of development of 100-octane number gasoline. Initially it was used, and still is, for hydrogenation of polymers such as di-isobutylene and hot acid polymer. The first catalytic base stock for use in high octane aviation fuels was produced through hydrogenation. More recently this process has been used for still further improving the quality of catalytically cracked aviation gasoline base stock.

▶ **Conclusions.** The developments in the manufacture of aviation fuel over the past few years have been truly remarkable. More adequate evaluation of quality is, however, necessary if we are to keep up with the increasing quality demands of the armed forces. The purpose for which the test stand has been built is to supply in part that need. Principal among its services shall be:

1. More accurate evaluation of the anti-knock quality of presently available constituents so that they may be most efficiently used in the manufacture of 100-octane number fuels and super fuels.

2. Evaluation of the quality of new and more powerful aviation fuel constituents during the time of their experimental development. ★ ★ ★

CONSTRUCTION FEATURES OF THE TENNESSEE GAS AND TRANSMISSION COMPANY PIPE LINE

By **FRANK H. LOVE,** Managing Editor

EXCLUSIVE FROM January 10, 1944, when the first main line pipe was welded, until October 29, 1944, when the last tie-in was made on the Tennessee Gas and Transmission Company system, a total of 293 days had elapsed. This is remarkably fast time for the construction of a pipe line 1265 miles in length, the longest gas pipe line to be laid in recent years. To accomplish this huge undertaking a total of 23 spreads was employed, which together with other contract work had on payroll 9000 to 11,000 workmen, involving approximately 25,000,000 manhours of labor.

The line originates at a point near Pintas Creek, Nueces County, Texas, and terminates at the Cornwell station of the Hope Natural Gas Company, about 5 miles east of Clendenin, West Virginia.

Beginning at Pintas Creek the line traverses the gulf coastal area of Texas in a northeasterly direction, passes just north of Houston, and after extending through eastern Texas crosses into Louisiana at a point near Jasper. The line then passes through the state of Louisiana south of Shreveport and north of Monroe, and crosses the Mississippi River at Greenville. From this point the line continues in a northeasterly direction, traversing the state of Mississippi just north of Batesville, the state of Tennessee north of Nashville, to a point near Danville, Kentucky. Here the route turns more sharply east and extends to a point near Catlettsburg, West Virginia. Here the line changes from 24-in. pipe to 20-in. and traverses West Virginia in a northeasterly direction to Cornwell station, West Virginia.

Of the total length of the line, 1265 miles, 1180 miles were laid of 24-in. pipe and 85 miles of 20-in. pipe.

The 24-in. section of the line was designed to operate under a maximum pressure of 750 lb. per sq. in. gauge, and the 20-in. section under a maximum pressure of 912 lb. per sq. in. gauge. At these pressures the safety factor of the pipe is 1.4 on the yield point and 1.95 on the bursting strength.

Seven compressor stations with a total installed horsepower of 58,000 have been constructed, but the ultimate design is for 14 stations with a total of 118,000 hp. The erected stations are at East Bernard, Texas; Jasper, Texas; Monroe, Louisiana; Batesville, Mississippi; Lobelville, Tennessee; Campbellsville, Kentucky, and Burnaugh, Kentucky, and a detailed description of these installations will be found elsewhere in this special section.

Capacity of the pipe line system into the Burnaugh station under the initial design, i.e., with 7 stations operating, is 207,000,000 cu. ft. a day at a pressure base of 14.73. Under the ultimate design, or with 14 stations operating, the capacity will be 262,000,000 cu. ft. a

Tying in a bend on section of line in West Virginia.

day. This is on the 24-in. section of the line. On the 20-in. section, or from Burnaugh station to Cornwell station, under the initial design the capacity is 155,000,000 to 165,000,000 cu. ft. a day at a pressure base of 14.73, and under the ultimate design will be 237,000,000 cu. ft. a day.

▸ **Difficult terrain.** In traversing 7 states the line was laid through virtually every known type of terrain. Sixty-seven major river and stream crossings were made, 24 of which required special installations, approximately 700 miles of forest and heavy undergrowth were traversed, 400 miles of rock soil and numerous swamps and lowlands were crossed, and many dangerous cliffs and precipices had to be avoided in the 600-mile section from Batesville, Mississippi, to Cornwell, West Virginia. To surmount these obstacles only the best of pipe-lining methods were employed.

▸ **Ditching and line cover.** Specifications called for a minimum trench width of 40 in. with a minimum coverage of 30 in. In rocky areas the minimum coverage was reduced to 24 in., but it was required that in such areas the pipe be given a padding of sand or dirt. In rocky terrain it also was necessary frequently to resort to blasting or the use of air hammers to make the trench.

▸ **Welding.** The entire line was welded, approximately 307 miles by the pressure weld method, the remainder by electric welding. In the case of the latter both rolling and position or "stove-pipe" methods of procedure were employed, as dictated by terrain and other factors. When the rolling weld method was used specifications called for three beads to be run. When position welding, four beads were called for and additional bead or beads if the weld did not meet specifications when tested. On river crossings a minimum of four beads was required including the stringer bead, and in addition all joints were reinforced by a split welding sleeve.

Line up clamp in pipe, set but not expanded.

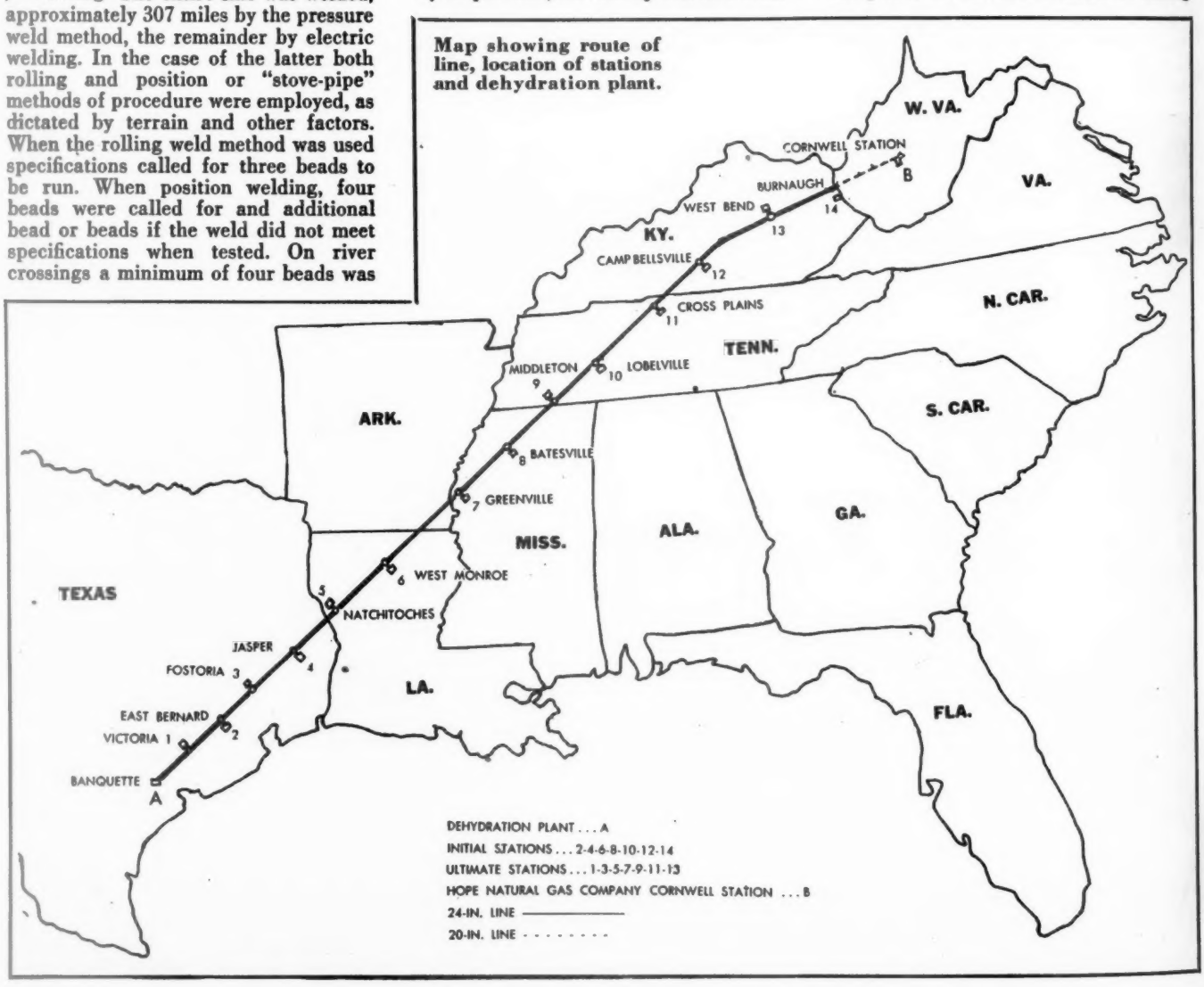
In connection with electric welding on the Tennessee line a new pipe-line development was introduced by one of the contracting firms, Bechtel-Dempsey-Price, an inside line-up clamp. The clamp, designed by B. V. Elliott, equipment superintendent for H. C. Price Company, is asserted to speed production by 25 per cent, the line-up and first bead being completed in four minutes with its use. The clamp is made in three segments, and is hydraulically expanded, forming a perfect circle against the inside wall of the pipe, resulting in a smooth joint for welding.

Within recent months almost all large diameter gas lines have been laid of thin walled line pipe. As a result it has been difficult to maintain the ends circular from the time the pipe leaves the manufacturing plant until it is ready to be welded. Distortion to the ends makes lining-up difficult, often making it necessary to cut off the bad ends thus wasting material as well as time. The new clamp, when expanded by hydraulic pressure, forces the pipe ends back to their original shape.

In operation, a single pump operates two hydraulic jacks. A small jack is raised to hold the clamp in place while inserting it in the second joint. After the two pipe sections are placed together, the large jack is raised to expand the three segments into a perfect circle, thus holding the pipe in correct alignment for welding.

Pressure welding, developed by A. L. Forbes beginning in 1940, articles on which have been published here and elsewhere, was used more extensively on this line than on any project since its inception. The method consists of fusing

Map showing route of line, location of stations and dehydration plant.



the ends of the pipe joints. The principal components of the equipment consist of a sideboom tractor equipped with the necessary hydraulic equipment for applying pressure when the pipe joints have been heated to the proper temperature, and a water cooling system; an acetylene generator and oxygen bottles mounted on a trailer drawn by the tractor; a clamp, and burner head. The hydraulic equipment and water cooling system are operated by power supplied by the tractor engine, and the tractor driver operates the hydraulic levers that give the required pressures to the clamp.

Experience has demonstrated that best results are obtained when the pipe ends have about an 8-degree outside bevel making an included angle of 16 degrees.

In making welds on the Tennessee line the pipe was heated to a temperature of approximately 2200° F. and the end pressure used to upset one joint into another was 4000 lb. per sq. in. of face surface. This amounted to a total pressure of 76,000 lb. being exerted on the joint.

Welds were tested for tensile strength, by the bend test for ductility and by the nick-break test to determine porosity and penetration.

Line pipe specifications. Line pipe was of three wall thicknesses, ¼ in. and 9/32 in. for the 24-in. main line pipe, 9/32 in. for the 20-in. main line pipe, and ⅜ in. on river crossings.

Richard Wagner
Chairman of board

The American Standards Association's code for pressure piping (gas and air piping), division 2, states that pipe may be operated up to 80 per cent of the mill test. Tennessee Gas and Transmission Company required that all pipe be tested to 90 per cent of the yield point. With the above specifications, therefore, the line was designed to operate at a maximum pressure of 72 per cent of the yield point of the steel.

In an effort to reduce the steel tonnage the War Production Board required that the line pipe contain a high manganese content and a high yield point. Due to the availability of manufacturing facilities, however, WPB prescribed that 300 miles of the 24-in. pipe and all 20-in. pipe be made in a mill where the highest yield point attainable was 45,000 lb., and that 900 miles of the 24-in. pipe be made in a mill in which the available yield point was 50,000 lb.

Wall thickness required for the 24-in. pipe having a yield point of 50,000 lb. was ¼ in., and for that made of steel having a yield point of 45,000 lb., 9/32 in. Wall thickness for the 20-in. pipe having a yield point of 45,000 lb. was 9/32 in.

The 20-in. pipe was used in the mountainous areas because the thicker walled pipe lends itself better to field bending and the type of construction necessary through that terrain.

Details of pipe steel specifications are given below.

The 24-in. O.D. National seamless pipe, 9/32-in. wall thickness, with theoretical weight of 71.25 lb. per ft., was manufactured in accordance with API line pipe specifications for 5-L Grade B pipe except as follows:

(Continued on Page 128)

TABLE 1
Summary of general data

Pipe diameter	Number miles		
Main line, 24-in	1180		
Main line, 20-in	85		
Pressures			
Maximum operating pressure, 24-in	750 lb. per sq. in. gauge		
Terminus pressure	475 lb. per sq. in. gauge		
Compressor station suction pressure	400 lb. per sq. in. gauge		
Compressor station discharge pressure	750 lb. per sq. in. gauge		
Capacity			
Initial design	207,000,000 cu. ft.		
Ultimate design	262,000,000 cu. ft.		
Cubic foot			
Absolute pressure	14.73 lb. per sq. in.		
Temperature	60° F. or 520° abs.		
Gravity	0.60		
Pipe line			
Outside diameter	24-in.	24-in.	20-in.
Wall thickness	9/32-in.	¼-in.	9/32-in.
Miles	300	880	85
Minimum yield point	45,000 lb.	50,000 lb.	45,000 lb.
Minimum tensile strength	70,000 lb.	70,000 lb.	70,000 lb.
Bursting pressure	1,641 lb.	1,458 lb.	1,968 lb.
Yield pressure	1,055 lb.	1,042 lb.	1,265 lb.
Safety factor on yield point	1.4	1.39	1.67
Safety factor on tensile strength	2.19	1.95	2.62
Pipe weight per mile of line, tons	188.1	167.41	156.37
Coatings	24 in.		
Miles	1079		
Coats of primer	1		
Coats of enamel	1		
Felt wrapper	1		
Compressor stations		Initial	Ultimate
Number of stations		7	14
Spacing, approximate miles		170	85
Total number of units		58	118
Total installed hp		58,000	118,000
Compressor ratio, average		1.83	1.54
System fuel consumption per day (12 cu. ft. per hp-hr. operated) Peak load conditions (M. cu. ft.)		16,704	33,984
Gas measuring stations			
Purchase gas stations	3		
Check meter stations	3		
Sales meter stations	3		
Main line valves			
Type	lubricated plug valves with welding ends		
Average spacing	10 miles		
Total installed	141 24-in., 8 20-in.		

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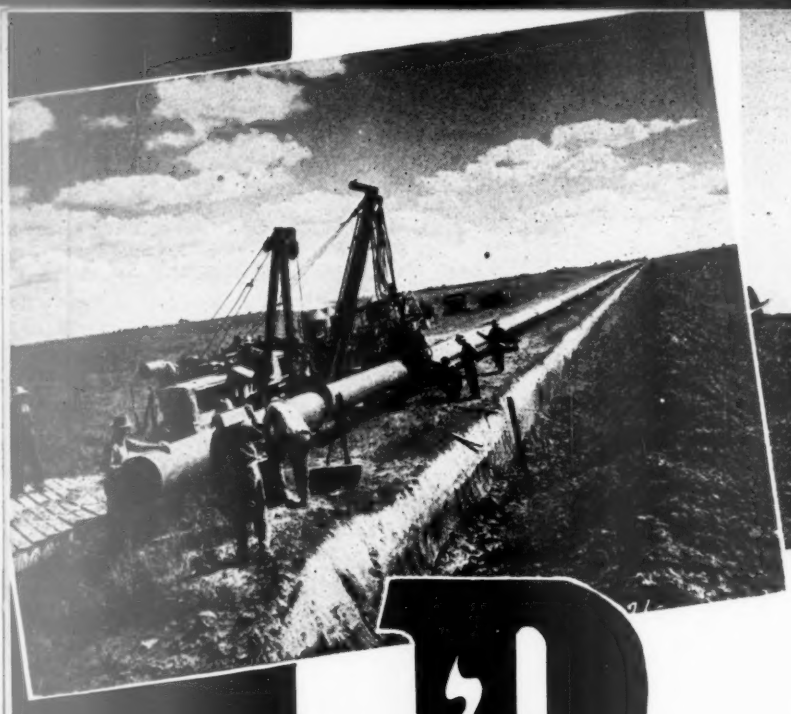

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Pressure Welded pipe line jobs have now been completed for the following firms:

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Phillips Petroleum Co.
Southern Pacific Co.
Tennessee Gas and Transmission Co.
Texas Pipe Line Co.
Tucson Gas, Electric Light & Power Co.
U. S. Bureau of Mines

You are cordially invited to ask them about the quality of the welding done and the savings effected by the use of Pressure Welding.

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SAVES TIME, MEN AND MONEY ON THE 320 MILE TEXAS SECTION OF TENNESSEE'S NEW PIPE LINE

Pressure Weld Clamps and crews, working with the four spreads of the three contractors on the 320 mile Texas section of this gigantic new pipeline from Corpus Christi to West Virginia, established spectacular records for speed, economy, and high quality welds. The work was done in a considerably shorter time with far less equipment and some 100 fewer men were required than if this section had been welded by older methods. The records established on the Tennessee and previous jobs have proven conclusively that Pressure Welding is the unrivalled modern way to weld pipe lines, whether they are large or small, short or long, high pressure or low, to carry natural gas, oil, water, other fluids or gases.

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Blowing a section of line before testing.

Ditching machine in operation through Texas area.

Draglines aided in making trench for river crossings.

Part of line was through rough country—in Kentucky.

(Continued from Page 125)

Minimum physical properties:
- Yield point ..... 45,000 lb.
- Tensile strength ..... 70,000 lb.
- Hydrostatic test (72 per cent yield point) ..... 950 lb. per sq. in.
- Random lengths average ..... 40 ft. or longer

Chemical limitations:
- Carbon not more than 0.30 per cent
- Manganese ..... 0.35-1.50 per cent
- Sulphur not more than 0.06 per cent
- Phorphorus not more than 0.045 per cent

The 20-in. O.D. National seamless pipe, 9/32-in. wall thickness and theoretical weight of 59.23 lb. per ft., was manufactured in accordance with API specifications for 5-L Grade B pipe except as follows:

Minimum physical properties:
- Yield point ..... 45,000 lb.
- Tensile strength ..... 70,000 lb.
- Hydrostatic test (72 per cent of yield point) ..... 1140 lb. per sq. in
- Random lengths average ..... 40 ft. or longer

Chemical limitations are the same as for 24-in. line pipe.

Specifications for 24-in. O.D. A. O. Smith electrically welded pipe, having ¼-in. wall thickness and a theoretical weight of 63.413 lb. per ft. were:

Minimum physical properties:
- Yield point ..... 50,000 lb.
- Tensile strength ..... 70,000 lb.
- Hydrostatic test (72 per cent of yield point) ..... 940 lb. per sq. in.
- Random lengths average ..... 40 ft. or longer

Chemical limitations:
- Carbon ..... 0.30 per cent maximum
- Manganese ..... 0.95-1.25 per cent
- Phosphorus ..... not more than 0.045 per cent
- Sulphur ..... not more than 0.050 per cent

Steel from which the line pipe was made was required to have a minimum tensile strength of 70,000 lb. and a minimum yield point of 41,250 lb. Each length of pipe, in its manufacture, was expanded hydraulically within dies to produce the nominal outside diameter. The pressure thus required produced a hoop stress in the circumferential direction of not less than 50,000 lb. per sq. in. minimum specified yield point in the finished pipe.

▶ **River crossings.** A total of 67 major rivers and streams are crossed by the line. Twenty-one of these are in Texas, 7 in Louisiana, 5 in Arkansas, 10 in Mississippi, 9 in Tennessee, 9 in Kentucky, and 6 in West Virginia. Twenty-four of the crossings required special installations, 6 being aerial pipe-line crossings.

Table 2 shows in tabulated form the name of the river, what state it is in, the type of crossing, number of lines, size of pipe, and the approximate length of each.

On the minor and less hazardous streams a single submerged crossing was used, the outside diameter of the pipe being the same as on the main line but the wall thickness being ⅜ in. On navigable and hazardous streams multiple line submerged crossings were installed. Such crossings consisted of three 16-in. O.D., ⅜-in. wall pipe when the main line was 24-in. in diameter, and two 16-in. O.D., ⅜-in. wall pipe when the main line was 20-in. in diameter. On the numerous

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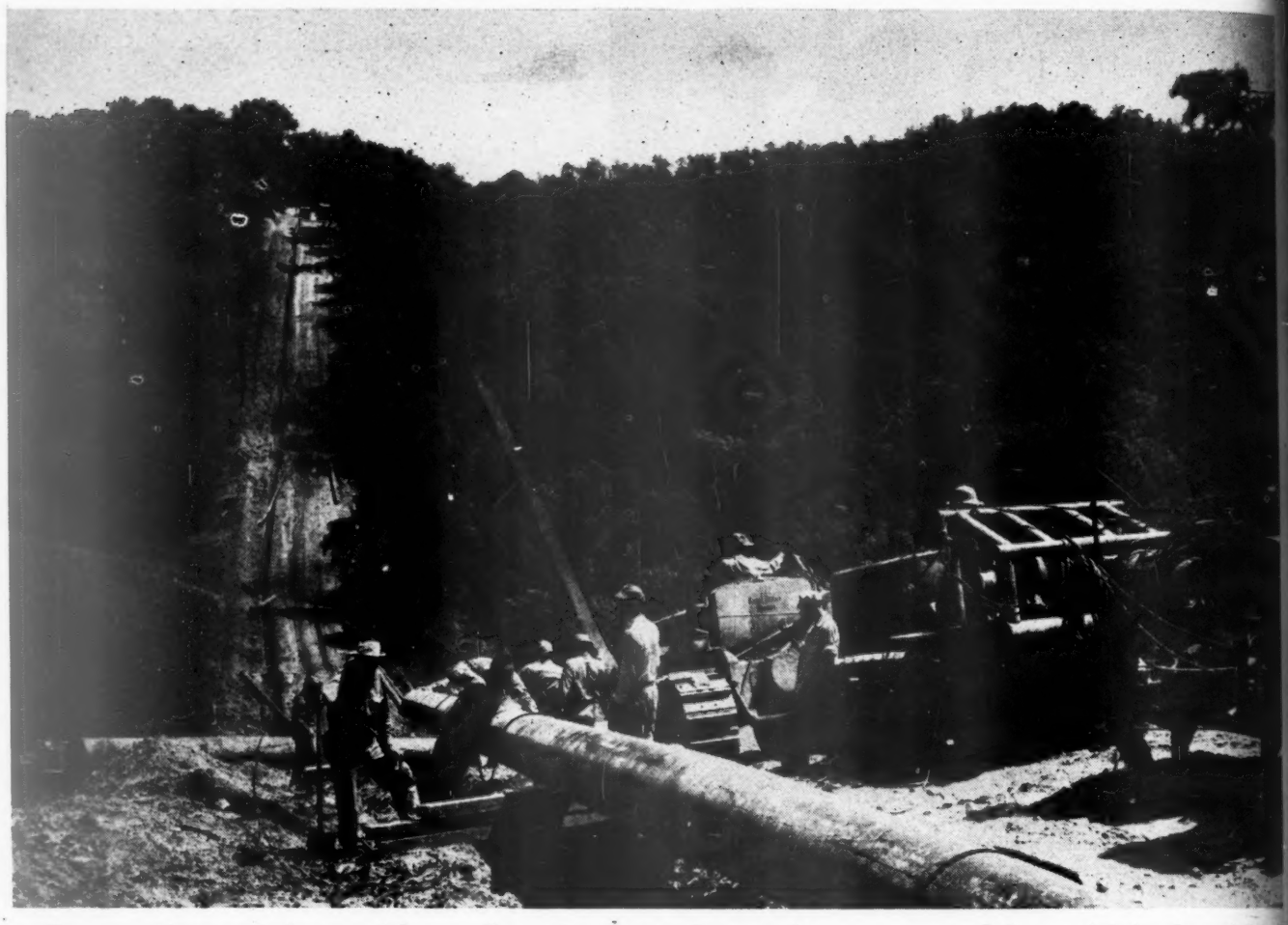


Stove-pipe construction at point near Huntington, West Virginia.

small streams that required no special installation, the crossing was laid with the line pipe being used on that section and consisted of a single line. On these narrower streams the pipe was pulled into place by tractors with winch lines after the pipe had been coated, wrapped, welded, and slats attached to protect the coating and wrapping. The wider river crossings were laid from barges, sections of pipe being welded on the barge and lowered into place in the trench previously dug in the river bottom.

On navigable rivers the government specifies a depth at which the line must be buried, usually about 10 ft. below the bottom of the river. In laying the Tennessee line this depth was exceeded, as it was desired that there be no possibility of the pipe becoming uncovered by washing action of the river or as a result of dredging. In the narrower streams the minimum covering was 4 ft. unless hard formation was encountered.

All river crossing pipe was weighed by river clamps. On 24-in. pipe the clamps weighed 4200 lb. each. When the pipe had a wall thickness of ¼ in. the clamps were spaced on 23-ft. centers; when of ⅜-in. thickness the spacing was up to 30 ft. Lighter weight clamps were used on the 16-in. multiple crossings where the wall thickness of the pipe was ⅜ in. These weighed 2300 lb. each and were spaced on 40-ft. centers.

Sleeves served to reinforce joints on river crossing pipe, the sleeving extending beyond the clamps, i.e., into the approaches.

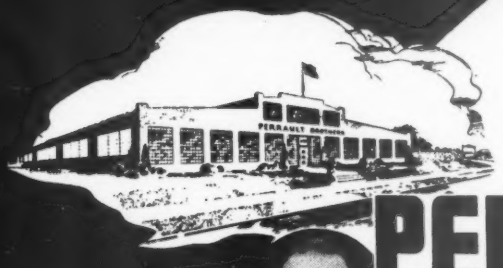
The Mississippi River crossing was made with two 18-in. lines carried on each side of the Greenville (Arkansas and Mississippi) toll bridge. The purpose of laying a line on each side of the bridge was to balance the weight on the trestle. An interesting point in connection with this crossing was the fact that aluminum alloy brackets and rollers were used in its construction, the purpose being to minimize the weight of such auxiliary equipment so that the weight of the pipe could be heavier. Pipe of two wall thicknesses and two weights was used. Pipe having ⅜-in. wall thickness has a weight of 70.589 lb. a ft. and that of ¼-in. wall thickness a weight of 47.393 lb. a ft.

Anchor blocks have been set on all multiple river crossings, at each 16-in. valve and behind each header. At each crossing where extensive high water may be expected a tower platform has been built over the gate valves. This tower extends 2 ft. above the known high water mark. The valves have been equipped with a long stem that extends

TABLE 2

River and major water crossings

State	Water crossing	Type of crossing	No. lines, size pipe	Approximate length, miles
Texas	Colorado River	Aerial	Single 24-in.	0.15
	Brazos River	Aerial	Single 24-in.	0.29
	Nueces River	Submerged	Single 24-in.	0.189
	Guadalupe River	Submerged	Three 16-in.	0.34
	Trinity River	Submerged	Three 16-in.	0.30
	Angelina River	Submerged	Three 16-in.	0.27
Texas and Louisiana	Sabine River	Aerial	Single 24-in.	0.15
Louisiana	Red River	Aerial	Single 24-in.	0.40
	Bayou D'Arbonne	Submerged	Three 16-in.	0.19
	Ouachita River	Submerged	Three 16-in.	0.26
	Clear Lake	Submerged	Three 16-in.	0.68
Arkansas and Mississippi	Mississippi River	Bridge	Two 18-in.	1.04
Mississippi	Sunflower River	Submerged	Single 24-in.	0.14
	Tallahatchie River	Submerged	Single 24-in.	0.14
Tennessee	Buffalo River	Aerial	Single 24-in.	0.13
	Tennessee River	Submerged	Three 16-in.	1.01
	Duck River	Submerged	Single 24-in.	0.10
	Cumberland River	Submerged	Three 16-in.	0.57
Kentucky	Dix River	Aerial	Single 24-in.	0.13
	Big Sandy River	Submerged	Two 16-in.	0.25
	Kentucky River	Submerged	Single 24-in.	0.17
West Virginia	Kanawha River	Submerged	Two 16-in.	0.28
	Elk River	Submerged	Single 20-in.	0.08



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PERFORMANCE is second nature with us . . . and, fortunately, with most of those with whom we do business. Thus, while Perrault machines maintain a uniformly high level of quality in cleaning, coating and wrapping pipe, a great deal is due to the fact that we work with some of the best names in pipelining. The "best names" are relatively few, but they rightly include Tennessee Gas and Transmission Company on whose line Perrault machines, in the hands of some of the best operators in the pipeline construction field, played such an important part. Our congratulations to everyone for a job well done.

PERRAULT BROTHERS—PIPE COATING AND WRAPPING MACHIN
1130 NORTH BOSTON • TULSA 6, OKLAHOMA •

AGENTS FOR
AMERICAN STEEL WORKS
TAR KETTLES
AND BURNERS

through the bottom of the platform, making it possible for a workman to reach the platform by boat and shut off the gas flow during high water should it be necessary. The blowoff valve also is equipped with an extension that can be operated from the platform. These platforms have been built at 9 major river crossings.

Coating and wrapping of river pipe, as well as construction of aerial crossings, are discussed in separate articles in this special section.

▸ **Highway and railroad crossings.** As would be expected in the case of a pipe line of this length, it was necessary to cross a great many highways and railroads. In fact, 274 highway and 62 railroad crossings were made. All railroads and the hard surfaced highways were bored and the 24-in. line pipe run inside 28-in. casing. Each end of the casing was closed by a Dresser coupling and vents installed. When permissible, county highways and side roads were ditched.

▸ **Pipe bending.** Cold wrinkle bending was employed entirely to make the pipe fit the contour of the terrain. Two types of machines were used. In the case of one machine a hydraulic shoe was placed inside the pipe. Pressure supplied by a pump connected to the shoe expanded the latter at the same time the pipe was being pulled externally by means of a gasoline engine equipped with winches, forcing the wrinkle outward.

The other machine employed a full circle outside bending shoe but no inside shoe. Both machines are shown in accompanying photographs.

The use of such equipment to make wrinkle bends cold has been found by experience to be a great time saver in the construction of pipe lines.

▸ **Electronic holiday detector.** To locate faults in coating, the Stearns electronic holiday detector was employed by all contractors. In checking for holidays the machine is rolled along the top of the pipe by a workman who operates a manual control, pushes the machine, and is an observer for one side of the pipe. The operator's helper serves as an observer on the opposite side.

An audible alarm is given when a holiday is found and the total number of holidays is registered on a meter.

The assembled equipment weighs about 120 lb. The instrument itself consists of a voltage generator, bell alarm, panel light indicators, register, and automatic controls. Other essential appurtenances are a wet cell storage battery, a carriage of cast aluminum having resilient rollers and insulated handles, a rotor assembly attached to the end of the carriage, which is used to propel the exploring electrode, an exploring electrode consisting of spring wire close wound and with connectors at the ends that are conveniently engaged and disengaged, and a trailing ground cable.

Uniform inspection is given regardless of terrain due to the fact that the equipment rides on the line.

The detector was designed and constructed by D. E. Stearns, engineer for the United Gas Pipe Line Company, several years ago and has been improved upon by him since that time.

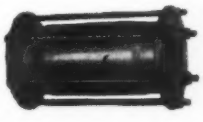
▸ **Main line block valves.** Worm gear operated lubricated plug valves have been installed on the main line at an average of every 10 miles, providing an immediate shut-off and minimum pressure drop through the valves. Although of main line size, these valves have a restricted area through the plug but are designed so that there is a venturi effect of the flow of gas through the valves, thereby producing a minimum pressure drop. The main line valve assemblies, as well as the river crossing headers, were completely prefabricated. The valves, having watertight 7-ft. gear extension, were installed without valve boxes. As soon as critical materials and fabricating facilities are available these valves will be equipped with automatic shut-off devices. In addition to the main line valves, automatic shut-off valves are to be installed at critical and inaccessible places on the line, a drop in pressure serving to close them and shut off flow of gas.

▸ **Testing the line.** As construction progressed, the line was tested for leaks in 10-mile sections. Before applying pressure a scraper was run through the line to clean it of foreign matter. This scraper, or "pig," which was propelled through the line by gas flow, scouring the pipe, removing dirt, mill scale, water and debris, was of special design. The body of the cleaning tool is of welded steel squirrel-cage construction with the ends closed. There are two steel wire brushes the bristles of which are made of high-carbon tempered steel. Two cups are made of synthetic rubber, are tough, oil-resistant and abrasion-resistent. One brush and cup are bolted together at

***Left*—Wrinkle bends of this type were all made cold. *Below*—The Mississippi River was crossed by carrying two 18-in. lines on the Greenville Bridge.**

A Complete Line MEANS Complete Service AND THAT'S DRESSER

DRESSER STYLE 38 COUPLING
For All Kinds of Plain-End Pipe Joining—Sizes ⅜" ID to 24" OD



DRESSER STYLE 40
Long Sleeve

DRESSER STYLE 39
Insulating Coupling

DRESSER STYLE 62
Reducing Coupling

DRESSER STYLE 83
Casing Bushing

DRESSER BELLMASTER
(Style 85)
For Cast Iron Pipe

DRESSER STYLE 90
Super-Service Fittings

The completeness of the Dresser line of pipeline products is an asset to everyone handling pipe. No matter how large or small the job, how simple or complicated, if pipe is to be joined—Dressers can join it.

Dresser makes over a hundred different pipeline products in every size from ¾" to 96" in diameter—couplings; fittings, repair clamps, sleeves. Every Dresser product is ready-made. Some require only the simplest assembly. Others are completely factory-assembled, all ready to slip on and tighten. In either case the only tool ever needed is a wrench.

To users of Dresser Products the versatility of the line, the complete size range, and the speed with which Dressers join or repair pipe mean time and money saved.

Send us your inquiries for any quantity—for any pipeline construction or maintenance work.

Save Man Power with Dresser Couplings

In Canada: Dresser Manufacturing Co., Ltd., 60 Front St., West, Toronto, Ont.

DRESSER MANUFACTURING COMPANY

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BRADFORD, PENNSYLVANIA

Houston Office and Warehouse: 1121 Rothwell St., Houston, Texas

each end of the scraper, supported by steel plates welded to the body.

The extremely stiff bristles enable the brush to loosen dirt and mill scale and to polish the pipe walls as the scraper is propelled through the line. The flexible lips of the rubber cups press uniformly against the pipe wall, wiping the surface clean. As the lips wear they are expanded by gas pressure and maintain a firm contact with the pipe. The weight of the scraper is carried by the brushes as well as the cups, thus reducing unit loading to a minimum.

A small hole in the rear end of the scraper body and perforations in the brush bodies permit a portion of the gas to bypass the scraper, purging brush bristles and blowing ahead the loosened dirt and scale. In a new pipe line this feature provides for safe gas-air mixture.

Finally, the short body of the equipment, unsupported in the middle, enables the scraper to traverse safely sharp pipe bends.

After the section of line was thus blown, the main line valves were set and a preliminary test pressure of 250 lb. applied, this pressure being allowed to remain for a minimum period of 24 hours. A dead weight gauge was connected to the section of line to indicate the gas pressure. A recording thermometer was also installed to give a record of temperature. Pressure readings were taken from the dead weight gauge at specified intervals, usually about every 30 minutes, to determine the rate of pressure drop. From this record of pressure drop and knowledge of temperature during the same time interval, the amount of gas leakage could be calculated.

The preliminary test was followed by a final pressure test of 800 lb. In addition the line was fire tested, which consisted of a workman walking the line with a torch. By this means holes were found that drop in pressure did not reveal.

▸ **Gathering system.** The gathering system consists of 15,500 ft. of 12¾-in. by 0.340-in. pipe, 25,500 ft. of 18-in. by ⅜-in. pipe, and 6,000 ft. of 10¾-in. by 5/16-in. pipe. The system connects the Wardner, Gulf Plains, and Coastal cycling plants, source of gas supply, with the dehydration plant, the capacity of the line ranging from 225,000,000 to 300,000,000 cu. ft. a day.

The system is designed to operate at 1000 lb. per sq. in. gauge at the Wardner and Gulf Plains cycling plants, and at 900 lb. per sq. in. gauge at the Coastal plant, delivering gas to the dehydration plant at a pressure of 800 lb. per sq. in. gauge.

▸ **Measuring stations.** The pipe-line system has been provided with three types of measuring stations: Purchase gas meter stations, sales meter stations, and check meter stations. The three initial purchase meter stations are in Nueces County, Texas. The stations at Wardner and Gulf Plains cycling plants are designed to operate under the initial design of the transmission system at a capacity of 100,000,000 cu. ft. a day at a pressure base of 16.7 lb. per sq. in. The measuring station at the Coastal plant is designed to operate at a capacity of 25,000,000 cu. ft. a day at a pressure base of 16.7 lb. per sq. in.

In the gas laboratory on the Texas end of the line, a gravitometer has been installed for recording specific gravity of the inlet gas. A calorimeter, installed at the same place, records the heat value of the inlet gas. A portable specific gravity balance also has been provided for the purpose of making tests at the various measuring stations.

There are three sales meter stations on the system, two for deliveries to the United Fuel Gas Company and one for deliveries to the Hope Natural Gas Company. The sales meter station situated at the discharge of compressor station No. 14, Burnaugh, Kentucky, delivers gas to United at a pressure of 475 lb. per sq. in. gauge and will handle between 35,000,000 and 45,000,000 cu. ft. of gas a day at a pressure base of 15.025 lb. per sq. in. Two of the sales metering stations are near the point at which the 20-in. main line crosses United Fuel Gas Company's S-7 12-in. line near Clendenin, West Virginia. One station delivers gas to United at a pressure of 475 lb. per sq. in. gauge and at a capacity of 55,000,000 to 65,000,000 cu. ft. a day, with a pressure base of 15.025 lb. per sq. in. The third station delivers gas to Hope Natural Gas Company at its Cornwell station, at a pressure of 475 lb. per sq. in. gauge with a pressure base of 15.025 lb. per sq. in. The capacity is 100,000,000 cu. ft. of gas a day.

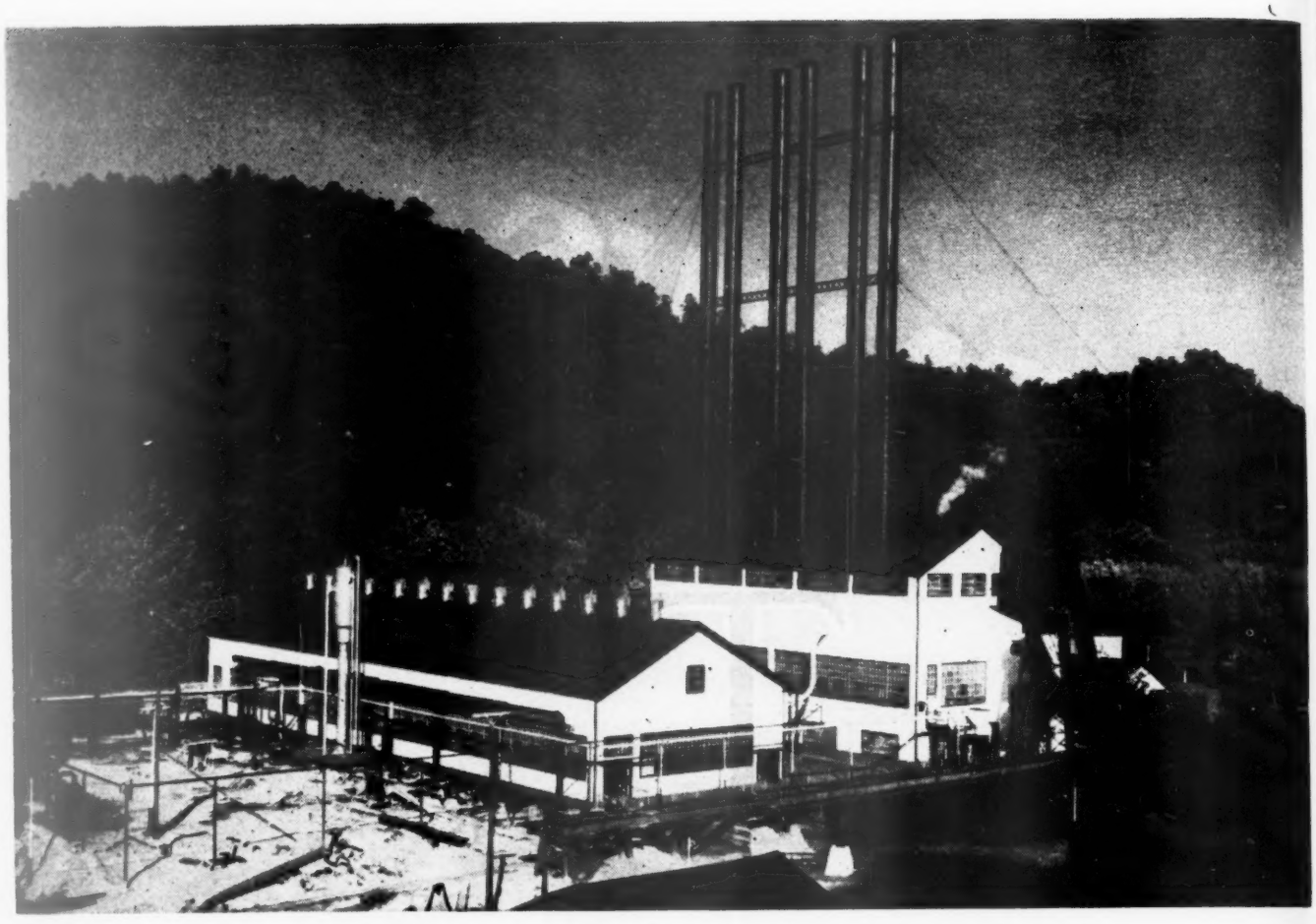
***Above*—Electric welding operator at work. *Below*—Rocky terrain requiring air hammers and hand workmen to make the ditch.**

At the measuring station near Burnaugh a recording gravitometer and a recording calorimeter have been installed in connection with the outlet measurement.

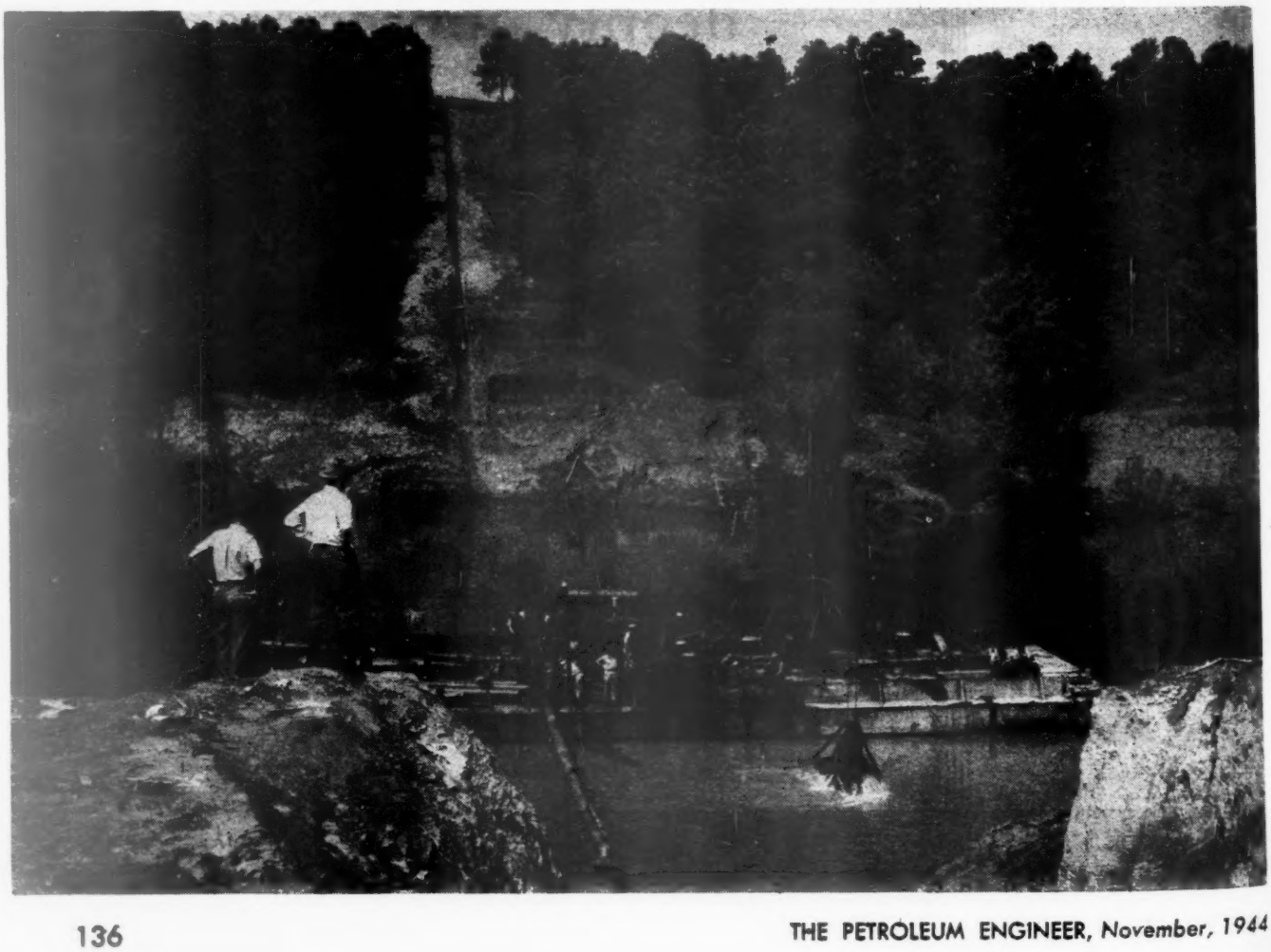
One check meter station is situated at the dehydration plant near Pintas Creek, Nueces County, Texas, another near Grand Ecore, Louisiana, and the third near Dickson, Tennessee. The station at the dehydration plant, in addition to functioning as a check meter station, also serves as proportioning meters in regulating the flow of gas to the contactors in the dehydration plant. This meter station is designed to operate at a pressure of 850 lb. and has a capacity under

THANKS

The job is finished. We deeply appreciate the fine cooperation of all who participated in this wartime project.



Above—Cornwell Station of Hope Natural Gas Company, terminal point of the line. *Below*—Using dragline and suction pump in making river crossing.



RUBEROID

Plays its part!

Ruberoid Asbestos Pipe Line Felt, being applied on the new, record-breaking, natural gas pipe line of the Tennessee Gas & Transmission Co.

• On pipe lines all over America, as on this latest "big inch," Ruberoid Asbestos Pipe Line Felt is doing its share to protect vital fuel arteries . . . just one of the many Ruberoid products giving indispensable service to the oil industry.

Ruberoid Asbestos Pipe Line Felt is specified by engineers because it gives maximum protection under the most severe conditions. It's chemically inert, moisture-resistant, protects from electrolysis.

For further details, write for our Industrial Bulletin "E."

RUBEROID

PIPE LINE FELT

Selling Agents for Oklahoma, Texas and Louisiana:
R. B. HALL AND COMPANY
Magnolia Building, Dallas 1, Texas

The RUBEROID Co.,
Executive Offices: 500 Fifth Ave., New York 18, N.Y.
Southern Office: Mobile, Alabama

PIPE LINE MATERIALS, THERMAL INSULATIONS AND BUILDING PRODUCTS

Two operations in pressure welding. *Bottom*—Lining up pipe. *Top*—Heating ends of joints before applying the pressure.

the initial design of the transmission system of 225,000,000 cu. ft. a day at a pressure base of 14.73 lb. per sq. in.

The stations at Grand Ecore and Dickson are designed to operate at a pressure of 750 lb. and at a capacity ranging from 225,000,000 to 300,000,000 cu. ft. a day at a pressure base of 14.73 lb. per sq. in.

These three stations were installed to provide a check on the amount of gas handled and to provide a means of isolating leakage in the system.

Gas used as fuel at the plants and in the cottages also is measured. Proportioning meters placed on the scrubbers at the inlet of each compressor station distribute the load to the scrubbers, and charts from the proportioning meters can be used as a station operating control check on the flow of gas into the plant.

▸ **Communications system.** The communications system consists of a single talking circuit leased from the American Telephone and Telegraph Company. At the Tennessee main office in Houston, Texas, there is a PBX termination, and a standard telephone termination has been installed at each of the compressor stations, at the northern division headquarters in Bowling Green, The Chicago Corporation office at Corpus Christi, the dehydration plant, each of the three delivery stations, and at the toll bridge office of the Greenville Mississippi River bridge. There is also local telephone service at each of the compressor stations, the main office, and the dehydration plant.

▸ **Employee housing.** A total of 27 employee houses have been constructed at the compressor stations and dehydration plant. There are four houses at each of compressor stations 2, 4, 8, 10, 12, and 14, two houses at station 6, and one at the dehydration plant. These houses were necessary because of the fact that some employees are on 24-hr. call, and also because of the remote location of the stations, which makes it impossible to house all employees in nearby towns.

▸ **General contractors.** General contractors consisted of the following:

Austin Bridge Company—Buffalo and Dix river aerial crossings.

Bechtel-Dempsey-Price — sections 7 and 9 of main line.

Brown and Root, Inc.—section 3 of main line.

Coastal Water Well Company—water wells at stations 2, 4, 6, and 8.

J. R. Horrigan Construction Company —sections 8, 9, and 10 of main line.

Elmer R. Lapsley — water wells at stations 10, 12, and 14.

Holloway Welding Works—tie-in to Southern Natural Gas Company on section 4 in Louisiana.

Henry Lemons and Company — gathering lines and pipe rack.

Midwestern Engineers—section 4 of main line, and submerged crossings on the Ouachita, Big Sandy, and Kanawha rivers, and Bayou D'Arbonne.

Pipe Line Construction Corporation—section 11 of main line, and submerged crossing of Elk River.

Pittsburgh-Des Moines Steel Company — aerial crossings of Colorado, Brazos, Sabine, and Red rivers, and installation of pipe on Greenville Bridge.

W. J. Riley—residences at compressor stations.

N. A. Saigh Company — sections 2 and 3, of main line.

Ray L. Smith Construction Company —section 4 of main line.

Linwood Smith—levee work on Mississippi River bridge crossing.

The Stearns-Roger Manufacturing Company—all compressor stations and warehouses at stations, dehydration plant, Wardner, Gulf Plains, and Coastal measuring and regulating stations, Louisiana and Tennessee check meter stations, and sales meter station No. 1 for United Fuel Gas Company at Burnaugh, Kentucky.

Swinerton-Walberg Company — section 8 of main line.

Williams Brothers Corporation—sections 1, 4, 5, 6, and 8 of main line, tie-in to Memphis Natural Gas Company at compressor station 7, submerged crossings of Nueces, Guadalupe, Trinity, Neches, Angelina, Sunflower, Tallahatchie, Tennessee, Duck, Cumberland, and Kentucky rivers, submerged crossing of Clear Lake, and low land pipe for Mississippi River bridge crossing.

▸ **Principal sub-contractors.** Principal sub-contractors were as follows:

J. B. Barbour Trucking Company — pipe stringing.

J. L. Cox and Company—pipe stringing.

5 Weeks to Spare

We completed . . . five weeks in advance of contract time limit . . . Section 2 (120 miles) of Tennessee Gas & Transmission Company's 24-inch natural gas line despite handicaps of quick-sand, rice fields and 40 inches of rain.

N. A. SAIGH COMPANY

PIPE LINE ENGINEERS AND CONTRACTORS

Professional Engineers
Assoc. Mem. A.S.C.E.

SAN ANTONIO, TEXAS

18 Years Experience
Over
4000 Miles Pipe Line

C. Hobson Dunn Company—pipe stringing.

Parkhill Truck Company—pipe stringing.

The Pressure Weld Company—welding of pipe.

C. S. Seal—clearing right-of-way.

J. R. Vanderveer and Son—pipe stringing.

Consultants. Consultants in engineering and accounting included:

Arthur Andersen and Company—consultants in connection with accounting system and installation, tax problems, and special audits.

Brokaw, Dixon and McKee—engineering consultants.

Matthews and Kenan—design of aerial suspension river crossings in Texas and Louisiana.

Parkhill-Wade (Henry N. Wade)—consultant of The Stearns-Roger Manufacturing Company in the design of compressor stations and the dehydration plant.

Starr Thayer — consultant on pipe coating and cathodic protection.

Engineering services. Engineering services were performed by:

Huey and Cage—survey and mapping of Louisiana, Arkansas, Mississippi, Tennessee, and Kentucky.

Moody Engineering Company — inspection of pipe at the mills.

Southern Mapping Company—survey and mapping of Texas and West Virginia.

Tobin Aerial Survey Company—aerial mosaic mapping of Texas and Louisiana.

Manufacturers and suppliers. Manufacturers and suppliers of equipment were as follows:

Allied Steel Products Corporation—steel buildings, fabricated structural steel and supports.

American Air Filter Company—intake filters and backfire relief valves.

Barrett Division of the Allied Chemical and Dye Corporation—primer and enamel.

Bethlehem Steel Co.—studs and nuts.

Bethlehem Supply Company—miscellaneous supplies.

Birmingham Tank Company — road crossing casing.

Blaw-Knox Company—fabricated piping.

Bowser, Inc.—oil pumps.

Buckeye Traction Ditcher Company—ditching machines.

Buffalo Pumps, Inc.—sump pumps.

Braden Steel Corporation—steel buildings.

Bucyrus-Erie Co.—bullgraders.

Byron-Jackson Company—centrifugal pumps.

Cardwell Mfg. Co.—sidebooms and backfillers.

Carey, Philip, Manfacturing Company—pipe line felt.

Caterpillar Tractor Company—tractors and bulldozers.

Chicago Bridge and Iron Works—tanks.

Cleveland Trencher Company—ditching machines.

Coastal Supply Company — miscellaneous supplies.

Continental Supply Company — miscellaneous supplies.

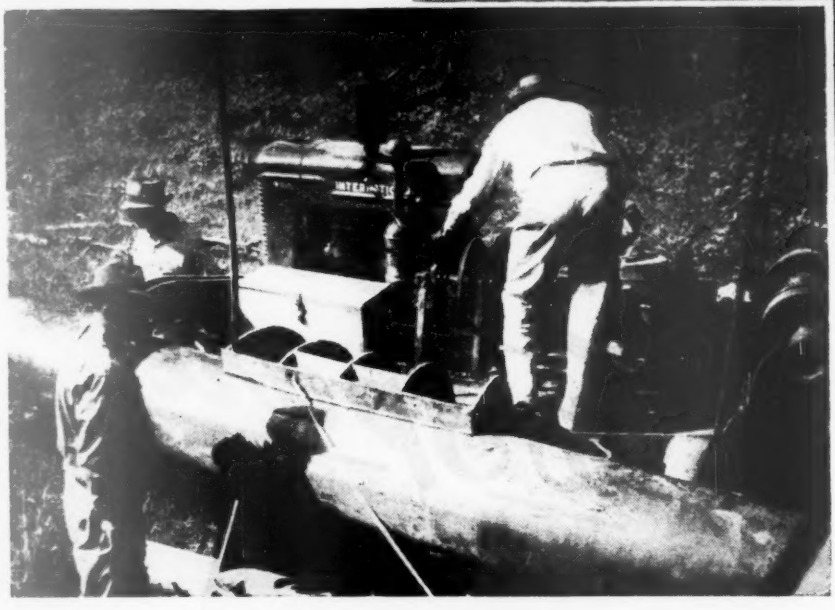
Cooper-Bessemer Corporation—gas compressors.

Crane Company, The—iron valves.

Crutcher-Rolfs-Cummings — pipe bending equipment, cleaning and priming machines, coating and wrapping machines.

Cyclone Fence Division of American Steel and Wire Company—steel fence.

Daniel Orifice Fitting Company—in-



All bends were made cold, two types of machines being used. *Above*—This machine employed a full circle outside bending shoe but no inside shoe. *Left*—A hydraulic shoe was used inside the pipe with this machine. *Below*—Main line valves.

TRENCHLINER

DIGGING TRENCHES...

. . . with the Parsons improved 250 Trenchliner gives you the advantage of full crawler traction for solid footing . . . multiple travel and digging speeds for easy or tough digging . . . long and wide crawlers . . . low ground pressure, approximately 7 pounds per square inch . . . digging depth of 12'-6" . . . digging width 16" to 42" . . . shiftable, telescopic boom . . . power shift arc conveyor. All of these and many more have proven the operating economy, high production ability and low maintenance cost records. Now is the time to prepare for economical trenching . . . with a modern Parsons Trenchliner.

THE PARSONS COMPANY
Newton, Iowa

Parsons Model 250

TRENCHING EQUIPMENT

PARSONS

C. Hobson Dunn Company—pipe stringing.

Parkhill Truck Company—pipe stringing.

The Pressure Weld Company—welding of pipe.

C. S. Seal—clearing right-of-way.

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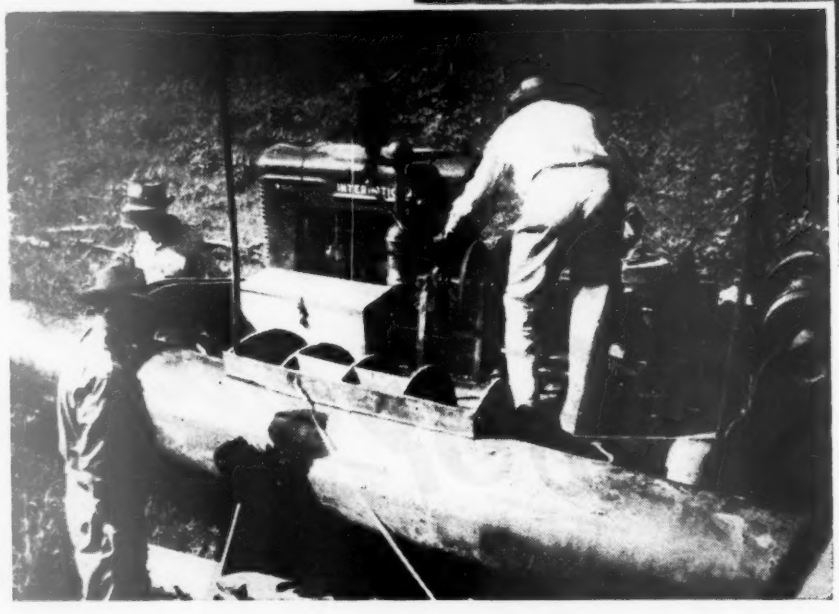

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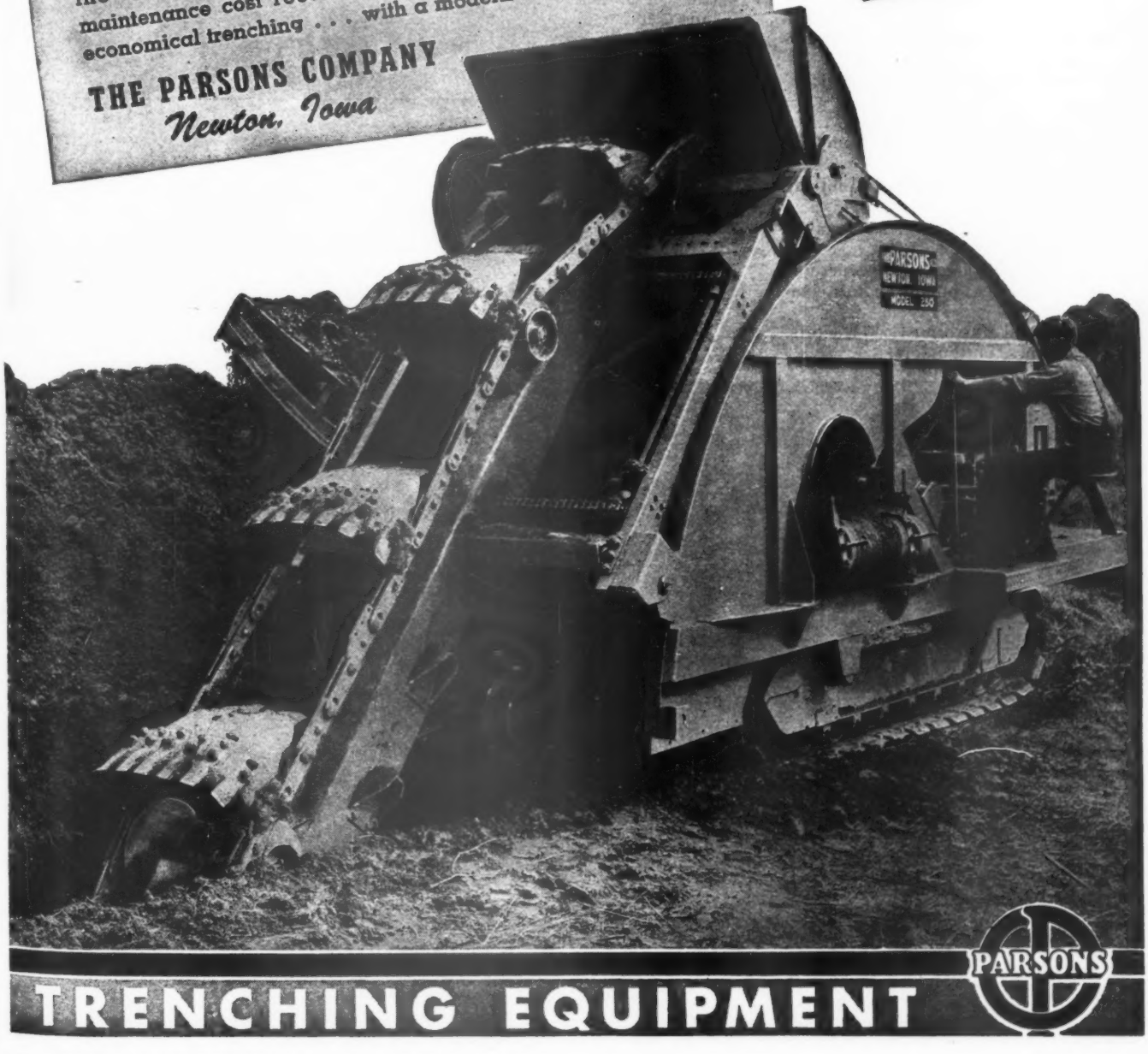
THE PARSONS COMPANY
Newton, Iowa

Parsons Model 250



TRENCHING EQUIPMENT

PARSONS

struments, gauges, controls, meters, meter runs and fittings.

Dresser Manufacturing Company — pipe sleeves and casing bushings.

E. Rowe Foundry and Machine Company—river clamps.

Fisher Governor Company—pressure regulators and engine governors.

Fisher Research Laboratories—pipe line locater.

Fleetweld-Big Three Welding Company—welding rod.

Fort Worth Structural Steel Company —fabricated structural steel and supports.

Foxboro Company, The—instruments, gauges and controls.

General Electric Supply Corporation —electrical supplies.

Glidden Company, The — electrical supplies.

Graybar Electric Company—electrical supplies.

Grinnell Co., The—welding fittings.

Griscom-Russell Co.—gas coolers.

Gustin-Bacon Manufacturing Company—fire fighting equipment.

Hampton, M. F., and Company—welding sleeves.

Hanlon-Waters, Inc.—pressure controls.

Hercules Supply Company—miscellaneous supplies.

Hilliard Corporation, The—oil purifying units.

Horn, A. C., Company—paint.

Horrigan, Jr., Construction Company —pipe bending equipment.

Houston Oil Field Material Company —miscellaneous supplies.

Houston Pipe and Steel Company—fabricated piping.

Ingersoll-Rand Company — generator engines, centrifugal pumps and air compressors.

International Harvester Co.—tractors, trucks, engines, bullgraders.

Johns-Manville Sales Corporation — pipe-line felt.

Kilbourn Engineering Company—studs and nuts.

Ladish Drop Forge Company—steel flanges.

Limbert, The George, Company—fabricated piping.

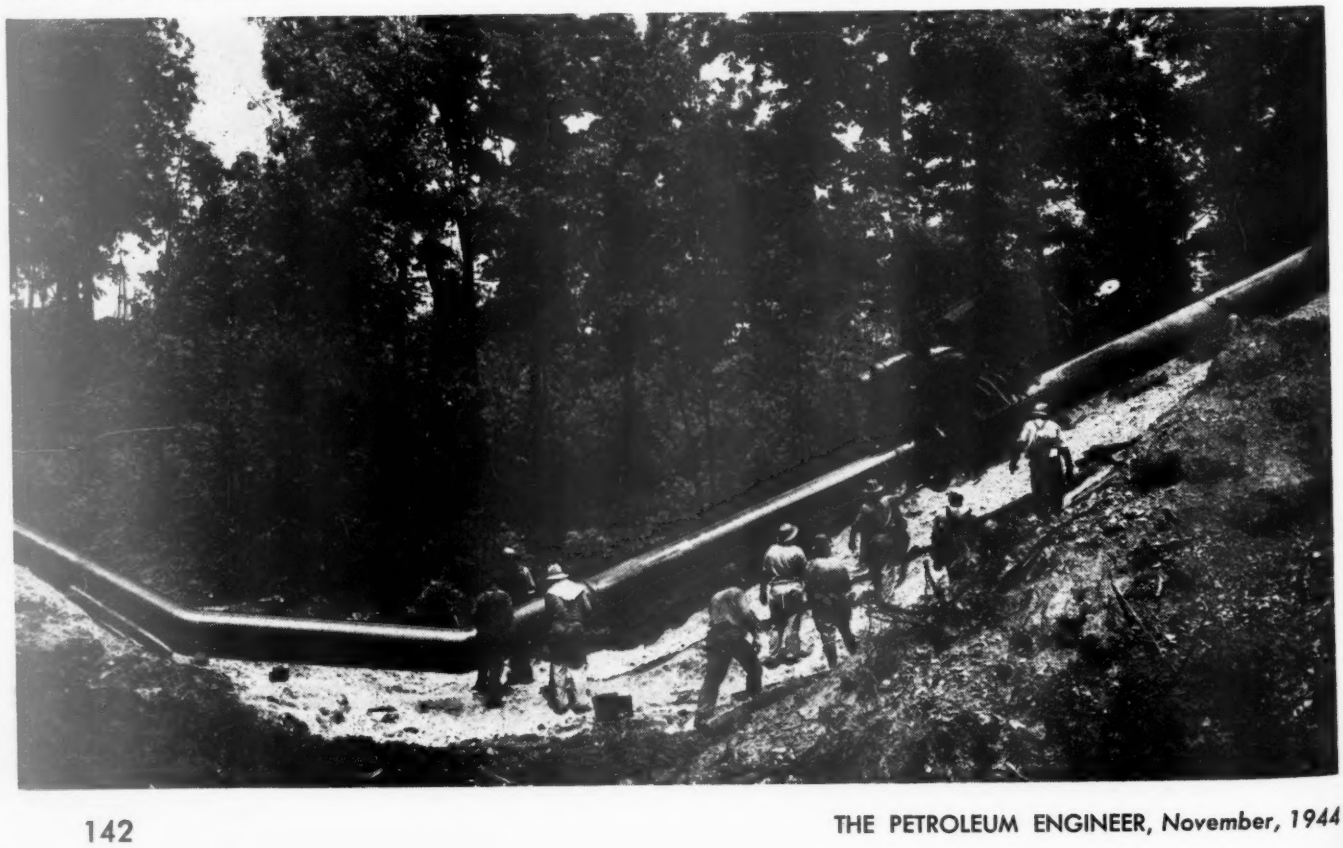
Lloyd Metal Foundry Company—river clamps.

Lunkenheimer Co.—brass valves.

Manning, Maxwell and Moore—pressure gauges.

Marley Company—cooling towers.

Maxim Silencer Company — exhaust silencers.



***Above*—Scraper that cleaned interior of pipe before sections were tested. *Below*—Cleaning machine negotiating a sharp sag.**

These people buy a battleship —every week!

Meet John S——— and Mary D———

John works at an electronics plant on Long Island, and makes $85 a week. Almost 16% of it goes into War Bonds.

Mary has been driving rivets into the hide of one bomber after another out at an airplane plant on the West Coast. She makes $55 a week, and puts 14% of it into War Bonds.

John and Mary are typical of more than 27 million Americans on the Payroll Savings Plan who, every single month, put a half a BILLION dollars into War Bonds. That's enough to buy one of those hundred-million-dollar battleships every week, with enough money for an aircraft carrier and three or four cruisers left over.

In addition, John and Mary and the other people on the Payroll Plan have been among the biggest buyers of *extra* Bonds in every War Loan Drive.

When you come to figure out the total job that John and Mary have done, it's a little staggering.

They've made the Payroll Savings Plan the backbone of the whole War Bond-selling program.

They've helped keep prices down and lick inflation.

They've financed a good share of our war effort all by themselves, and they've tucked away billions of dollars in savings that are going to come in mighty handy for both them and their country later on.

When this war is finally won, and we start giving credit where credit is due, don't forget John and Mary. After the fighting men, they deserve a place right at the top of the list. They've earned it.

You've backed the attack—now speed the Victory!

WILLIAMS BROS. CORP.

GENERAL CONTRACTORS ENGINEERS

Oil • Gas • Gasoline • Water

Pipe Lines and Pump Stations

NEW YORK • TULSA • ATLANTA • HOUSTON

This is an official U.S. Treasury advertisement—prepared under auspices of Treasury Department and War Advertising Council

McCann Steel Company — fabricated structural steel and supports.

Merco-Nordstrom Valve Company—plug valves.

Merkin, H. J., Paint Company—paint.

Mosher Steel Company — fabricated structural steel and supports.

National Supply Company — miscellaneous supplies.

National Tube Company—pipe.

Niland, Tom, Equipment Company—instrument boards and flywheel guards.

Noland Company, The — fabricated piping.

Oil Tool Manufacturing Company—miscellaneous supplies.

Parsons Co.—ditching machines.

Peden Iron and Steel Company—miscellaneous supplies.

Pelican Well Tool and Supply Company—welding fittings.

Penberthy Injector Company—liquid level gauges.

Pennsylvania Forge Company—welding fittings.

Perrault Brothers—coating and wrapping machines.

Pittsburgh-Equitable Meter Company—orifice meters.

Refinery Supply Company — miscellaneous supplies.

Republic Steel Corporation—pipe.

Republic Supply Company — miscellaneous supplies.

Rex Supply Company—studs, nuts.

Roebling's Sons Co., John A.—cables and suspenders on aerial crossings.

Ruberoid Company—pipe line felt.

Smith, A. O., Corporation—pipe, road crossing casing, welding fittings and welding rod.

Southern Electric Supply Company—electrical supplies.

Standard Asbestos Manufacturing Company—asbestos insulation.

Standco Bolt Co.—studs and nuts.

Stearns-Roger Manufacturing Company, The—pressure vessels.

Taylor Forge Co.—welding fittings.

Trimount Instrument Co.—gauges.

Tube Turns, Inc.—welding fittings.

Wailes-Dove Hermiston Corporation—primer and enamel.

Warren Electric Company—electrical supplies.

Westinghouse Electric and Manufacturing Company — generators, electric motors and exciters; cathodic protection equipment.

Williamson, T. D., Inc.—scraper.

W-K-M Company—cleaning and priming machines.

Worthington Pump and Machinery Corporation — gas compressors, generator engines, centrifugal pumps and air compressors.

Wright Manufacturing Division of American Chain and Cable Company—chain hoist.

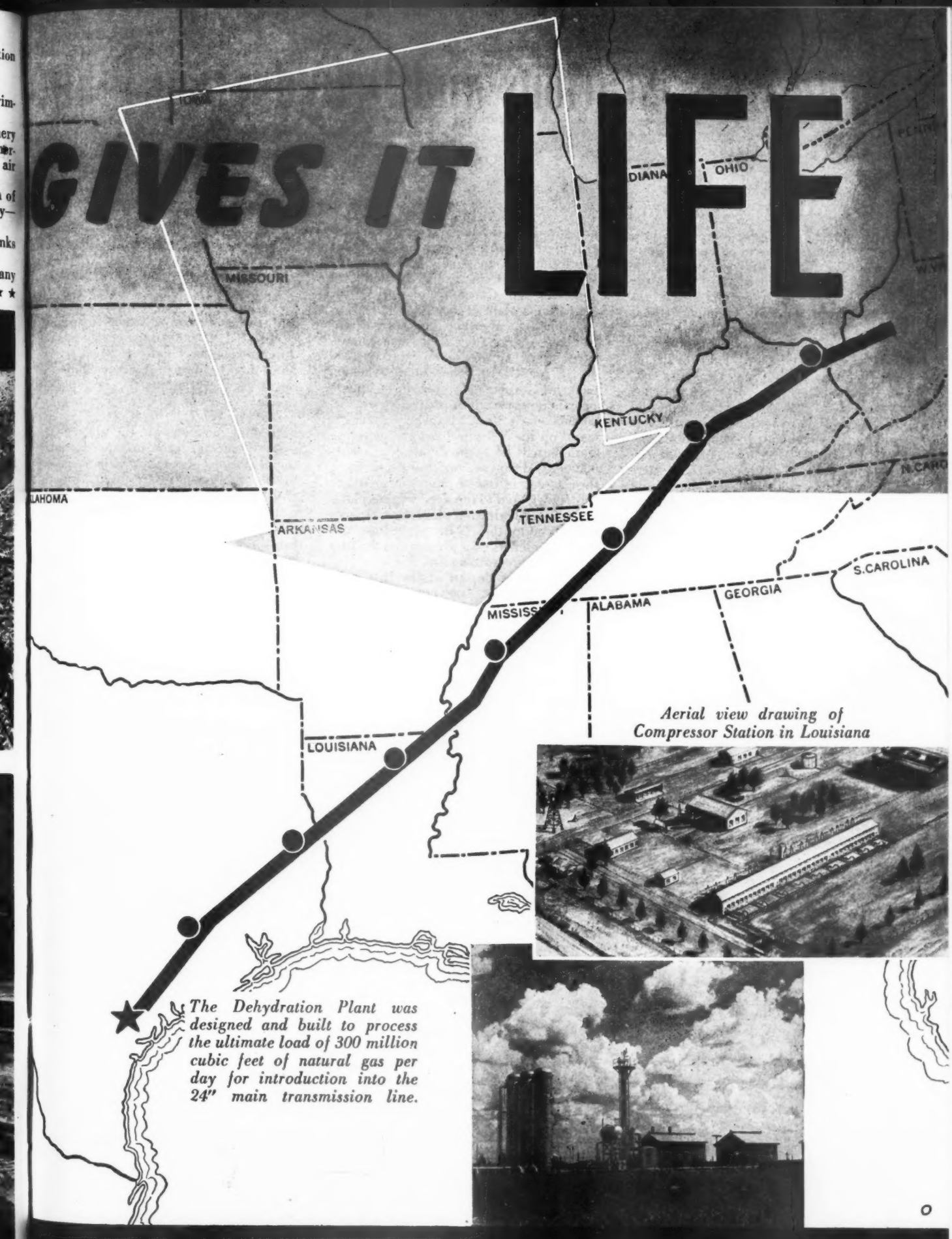
Wyatt Metal and Boiler Works—tanks and road crossing casing.

Youngstown Sheet and Tube Company—pipe.

★ ★ ★

Right—Casing a road crossing.
Below—Making a lake crossing.

GIVES IT LIFE



Aerial view drawing of Compressor Station in Louisiana

The Dehydration Plant was designed and built to process the ultimate load of 300 million cubic feet of natural gas per day for introduction into the 24" main transmission line.

MFG. COMPANY DENVER, COLORADO

Compressor Stations and Dehydration Plant

By HAROLD F. DAWE* and HENRY N. WADE†

THE construction program of the Tennessee Gas and Transmission Company 24-in. pipe line included 7 compressor stations and a dehydration plant. In the 7 stations, 6 will recompress the gas through approximately the same ratio at 1.86, whereas the last station will compress the gas to two different pressures at approximately 900 lb. and 475 lb. for split deliveries into the receiving systems. Under its own pressure the gas will move into the dehydration plant and to the suction side of the first compressor station situated about 160 miles down the line. The average spacing between stations is about 169 miles, with the spacing increasing slightly as distances from the source increase. The stations were spaced according to calculations based upon the best pipe-line economics, and in an overall pipe-line length of 1179 miles of 24 in. pipe. The exact geographical location, spacing, and compression ratios of the compressor stations are tabulated in Table 1.

At present, the gas enters 3 purchase gas metering stations under natural well pressure after it has passed through several high pressure absorption plants for extracting the gasoline, situated at the Wardner and Coastal cycling plants of The Chicago Corporation and at the Gulf Plains plant of the Gulf Plains Corporation. The Wardner and Gulf Plains metering stations each has a maximum capacity of approximately 150,000,000 cu. ft. per 24 hr. whereas the Coastal metering station may operate at an approximate maximum capacity of 75,000,000 cu. ft. per 24 hr. The present demand on these 3 purchase gas metering stations will be approximately 225,000,000 cu. ft. From the purchasing stations, the gas enters into a pipe system where it is transferred to the dehydration plant. From the dehydration plant the gas flows directly into the 24-in. pipe line and thence under its own pressure to the first of the compressor stations.

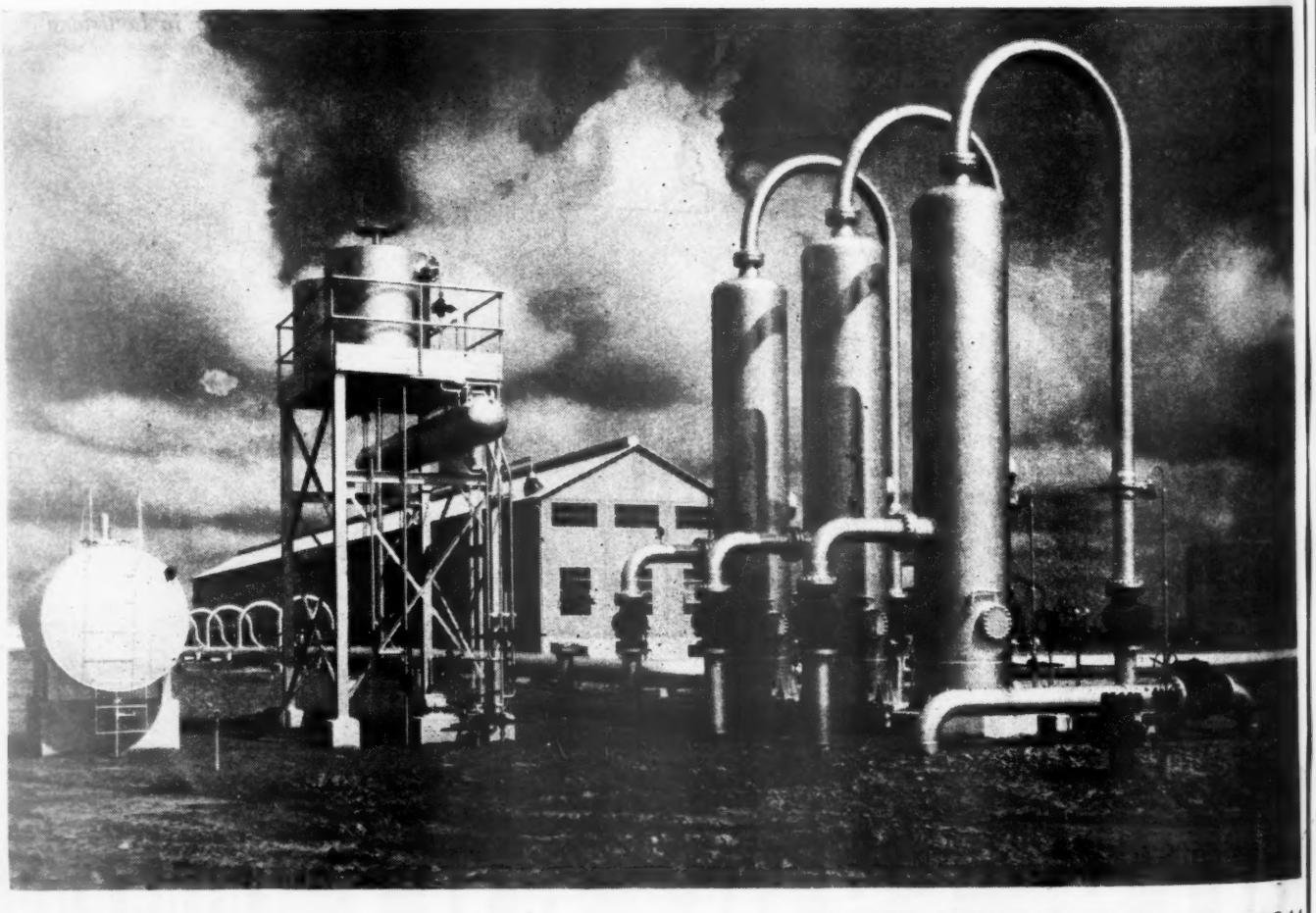
The present design of the line calls for delivery of 207,000,000 cu. ft. per 24 hr. of natural gas to the last station. From the last station 150-165,000,000 cu. ft. per 24 hr. will be delivered through a 20-in. pipe line to the Hope Natural Gas Company, Cornwell station, and 35-45,000,000 cu. ft. per 24 hr. will be sent through a 12-in. pipe line to the United Fuel Gas Company, near Clendenin, West Virginia.

The ultimate design contemplates that 293,500,000 cu. ft. per 24 hr. will enter the pipe line at the dehydration plant and the last station will receive approximately 262,000,000 cu. ft. per 24 hr. The difference between delivered fuel and entered fuel is due to fuel consumed in operating the pipe line.

The 7 stations, at present, are numbered evenly, 2, 4, 6, 8, etc. This has been done in order that the ultimate design, which calls for interposing additional stations ahead of and between the present stations, will result in consecutive numbering, 1, 2, 3, 4, 5, etc.

The purchase gas metering stations, the dehydration plant, and the 7 compressor stations were designed and constructed by The Stearns-Roger Manufacturing Company, and Parkhill and Wade were general consultants. In general, the design of the transmission line and compressor stations has followed

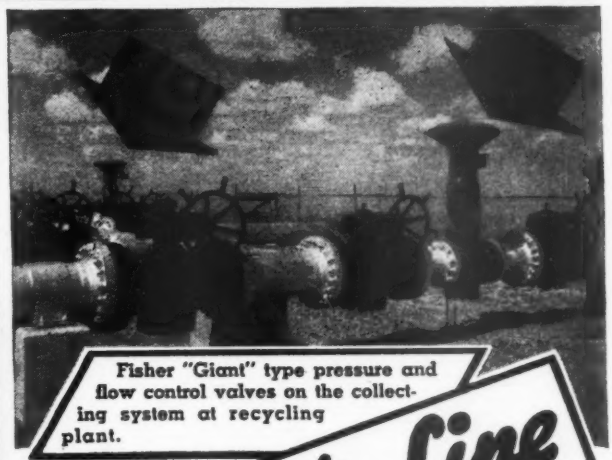
*Gas Engineer with The Stearns-Roger Manufacturing Company, Denver, Colorado.
†Chief Engineer, Parkhill and Wade, Los Angeles, California.



Scrubbers at East Bernard, Texas; compressor building in background.

ILLUSTRATING ONLY A FEW OF HUNDREDS OF FISHER CONTROLLERS ON THE TENNESSEE GAS & TRANSMISSION CO. PIPE LINE

Fisher fuel gas control regulators on generator engines at a Mississippi station.



Fisher "Giant" type pressure and flow control valves on the collecting system at recycling plant.

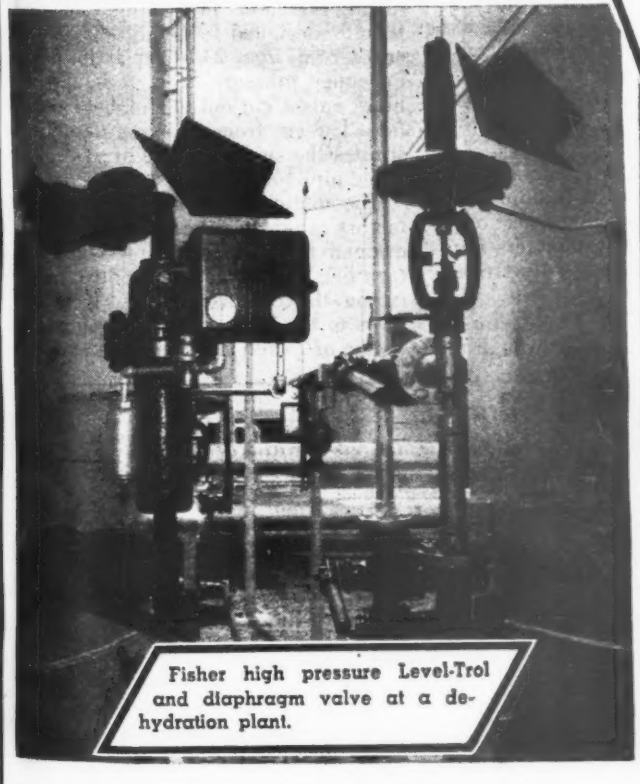
all along the Line

FISHER "GIANT" TYPE DIAPHRAGM VALVES TO SMALLEST GAS PRESSURE CONTROLLERS

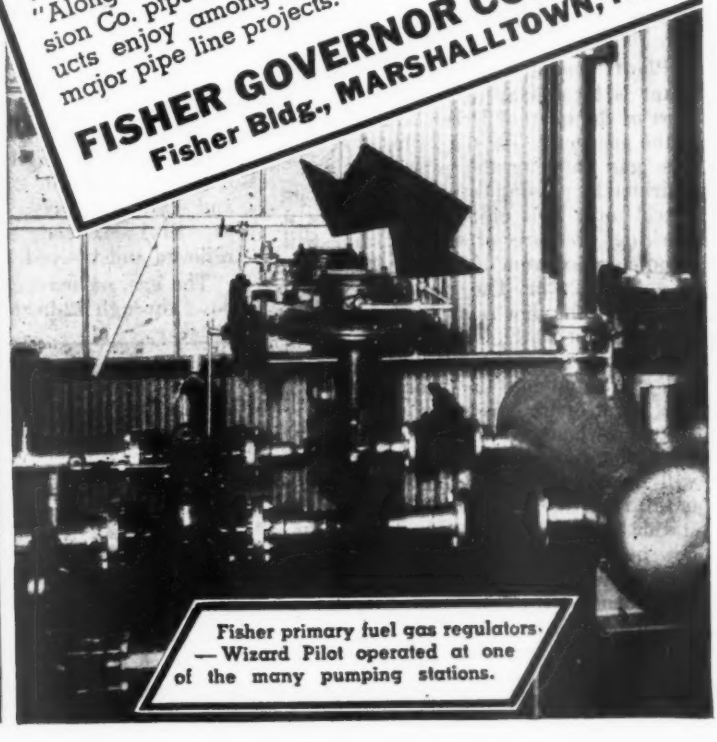
From the day of initial plans to its first operation the selection of automatic controllers has been an all important consideration in the successful completion of the greatest of all natural gas pipe lines.

The hundreds of applications of liquid level controls, pressure regulators, fuel governors, diaphragm control valves and various other Fisher specialties to be found "Along the Line" on the Tennessee Gas and Transmission Co. pipe line, illustrates the "priority" Fisher products enjoy among those who specify equipment for major pipe line projects.

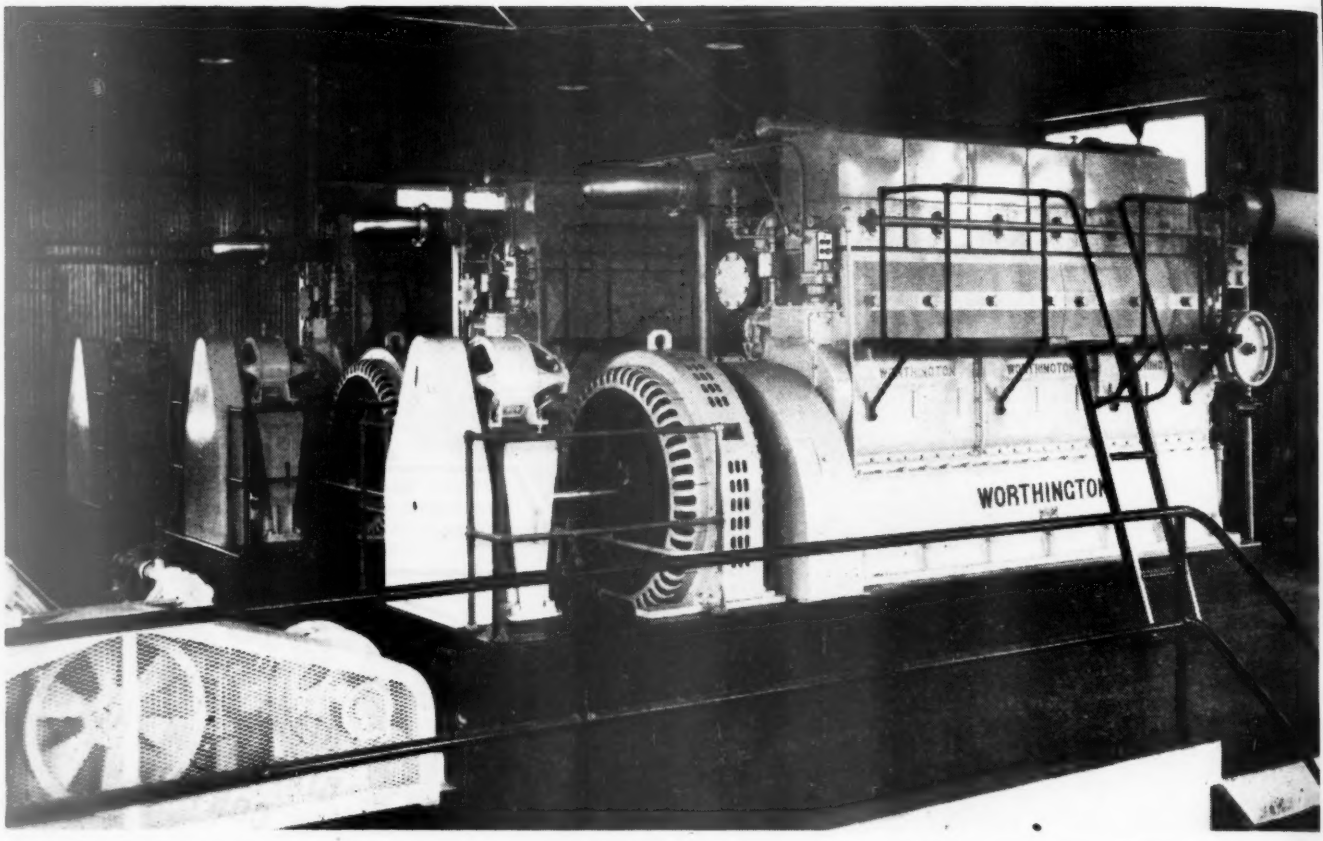
FISHER GOVERNOR COMPANY
Fisher Bldg., MARSHALLTOWN, IOWA



Fisher high pressure Level-Trol and diaphragm valve at a dehydration plant.



Fisher primary fuel gas regulators — Wizard Pilot operated at one of the many pumping stations.



Auxiliary engines.

lines intended to result in the utmost savings in material and labor consistent with safe and economical operation. It is felt that the following resume of some of the engineering details may be of interest and value at this time.

DEHYDRATION PLANT

Design of piping. The piping at the dehydration plant was designed according to Section 3, Division 2, of the Code for Pressure Piping promulgated by the American Standard Association under the designation ASA-B-31.1-1942. This design made use of the standard setup in this section for oil and gas piping inside refinery limits.

Plant description. The dehydration plant is located approximately 5 miles west of the town of Driscoll, Texas, and is the gas source for the 24-in. pipe line. The gas entering the pipe line is dehydrated by passing through a diethylene glycol unit. This unit is designed for a working pressure of 840 lb. and will handle a maximum of 300,000,000 cu. ft. of gas per 24 hr. The plant is designed to depress the dew point of the gas processed about 50°F., below the incoming temperature, which will be 80°F., or below, throughout the year. Thus, the dew point of the gas in all parts of the system will not be more than 30°F. at the outlet of the compressor stations and will decline somewhat below this temperature as the pressure drops between stations. Experience has shown that this dew point is adequate to protect against freezing or the formation of hydrates on all transmission lines, except possibly in one or two of the coldest, most northerly, parts of the country. The flow sheet for the dehydration plant is given on Page 158.

The gas enters the dehydration plant through an 18-in. pipe line with pressure reduced from 900 to 840 lb. through 8-in. pressure reducing regulators, in duplicate. Each regulator is designed to handle 225,000,000 cu. ft. per 24 hr., with a 35-lb. pressure drop. A bypass cuts out one or both of the regulators.

The gas from the regulators enters an 18-in. header and flows into a battery of 3 contactors in parallel, where the gas is intimately contacted with concentrated diethylene glycol, which, being hygroscopic, absorbs moisture present in the natural gas, and thus depresses the dew point.

The contactors are 78 in. in diam. and have a net shell length of 31 ft. 6 in. The units each contain 2 scrubber sections and 4 contact trays. The contactors are of API-ASME code design, fully stress relieved and x-rayed.

The gas, on leaving the 3 contactors, flows through 12-in. pipe and through a 12-in. meter run. There is a recording flow-meter on each run and a recording thermometer installed on 2 of the 3 runs. The recording thermometers are so arranged that one unit covers two runs for check purposes. These runs constitute the principal meeting point at present for all gas entering the 24-in. line.

The gas leaving the meter runs is conducted through a header to a duplicate regulator setting where the pressure is reduced from 825 to 750 lb. through either or both of two 8-in. pressure reducing regulators in parallel. Each regulator is designed to handle 300,000,000 cu. ft. of gas per 24 hr. at 75 lb. per sq. in. gauge pressure drop. A bypass and block valves cut out one or both regulators. The gas from these regulators constitutes the supply source of gas for the 24-in. pipe line.

The diethylene glycol from the contactors, slightly diluted with water, is drained from the contactors into a return line by a liquid level control mounted on the contactor. The glycol then flows to the heat exchange system, consisting of 7 shell-and-tube heat exchange

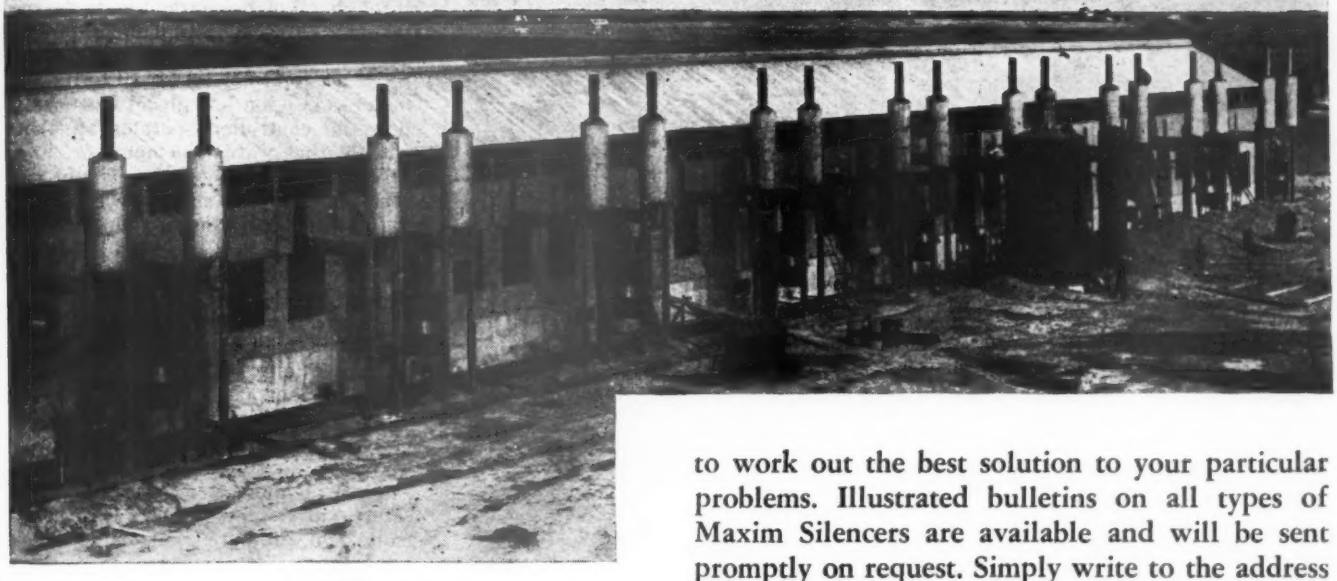
TABLE 1

Design data—compressor stations—initial design

Station number	Location	Miles station to station	Horsepower required	Installed horsepower	No. of units	Pressure absolute		Compression ratio.
						Suction	Discharge*	
2	East Bernard, Texas	162.57	8,801	9,000	9	410	760	1.86
4	Jasper, Texas	157.40	8,696	9,000	9	416	759	1.86
6	West Monroe, Louisiana	160.10	8,592	9,000	9	416	772	1.86
8	Batesville, Mississippi	173.81	8,676	8,000	8	409	772	1.89
10	Lobelville, Tennessee	166.70	7,685	8,000	8	438	772	1.76
12	Campbellsville, Kentucky	178.63	8,234	8,000	8	416	769	1.85
14	Burnaugh, Kentucky	180.70	7,042	7,000	7	416	761	1.83
	Total	1179.91	57,726	58,000	58			

*Pressure base. 14.73 lb. per sq. in. abs.

MAXIM SILENCERS ON ALL COMPRESSOR STATIONS OF LONGEST GAS PIPE LINE SINCE 1932



The longest gas pipe line since 1932, built by Tennessee Gas and Transmission Co., extends from Corpus Christi, Texas to Cornwall Station, West Virginia, a distance of 1265 miles.

Along the line seven compressor stations maintain the pressure in the 24-inch pipe which is designed for an operating pressure of 750 pounds. All of these stations are completely equipped with Maxim Silencers as shown above on the Bernard, Texas, station.

Wherever there is need for silencing, on engine exhaust, compressor intake, blowers, steam or air discharge, Maxims can be counted on to give long, trouble free service. Maxim engineers will be glad to work out the best solution to your particular problems. Illustrated bulletins on all types of Maxim Silencers are available and will be sent promptly on request. Simply write to the address listed below, giving details of the job you want to do.

* * * * *

A new development, Maxim Heat Recovery Silencers, provide in addition to silencing, the recovery of waste exhaust heat to produce steam or hot water for heating or processing operations. Heat Recovery Silencers are described in Maxim Bulletins WH-100, WH-101, WH-102 and WH-103.

ARMY E NAVY

THE MAXIM SILENCER COMPANY
90 Homestead Ave., Hartford, Conn.

MAXIM

units in series, where it flows through the tubes and is heated by the reconcentrated glycol from the still.

Between the second and third exchanger units in the series, the glycol is passed through a reflux condenser mounted on the top of the glycol still. This condenser serves to condense water reflux for the still from the water vapor, and further heats the glycol. This reflux condenser may be partially bypassed by a vernier hand control valve, as required. The glycol then returns to the third exchanger unit and flows through the remaining units, extracting additional heat from the lean glycol until it finally enters the glycol still feed tray.

The glycol still is 30 in. in diam. and has a net shell length of 32 ft. 6 in., with a 10-ft. skirt. The vessel has 15 bubble trays, is designed for a working pressure of 50 lb. and is equipped with a safety ladder leading to the platform and condenser support at the top.

A chordal weir baffle in the still serves to keep the glycol reboiler flooded over the level of the tubes, maintaining heating at maximum efficiency. The reboiler is of the vertical type and connects to the still by 12 in. top and bottom nozzles. It is 24 in. in diam. and has a net shell length of 6 ft. 10 in. The shell thickness is ¼ in. There are 454 ¾-in.—16-gauge tubes 48 in. long installed between 2 tube sheets, presenting an internal transfer surface of approximately 300 sq. ft. The reboiler is designed for 50 lb. working pressure at a temperature of 550° F.

The lean glycol flowing from the base of the still enters a 60-in. diam. surge tank having a net shell length of 8 ft. This vessel is mounted horizontally to make the maximum use of the tank surge space. This vessel serves to maintain an even head on the lean glycol through the heat exchangers, and to the suction of the glycol pump. It also acts as reserveir, or surge space, for the entire solution circulating system.

The lean glycol, after passing through the heat exchangers, is pumped back over the contactors. The pump used for this service is a 3¾ in. by 5 in. triplex plunger type, driven by a 40-hp., 440-volt, 60-cycle, open frame electric motor, with a complete spare unit.

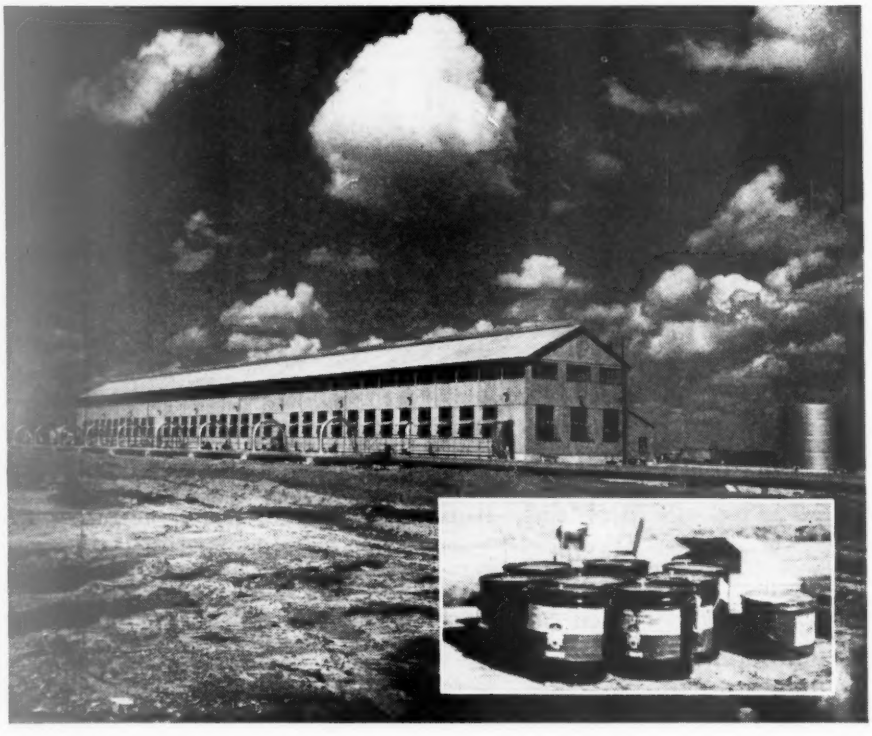
This pump forces the lean glycol through a 3-in. discharge line to the contactors. The lean glycol flows through a flow recorder controller that records the exact total flow of glycol to the contactors. Also, on low glycol flow or failure, the controller operates an alarm whistle that warns the operator. From this point, the glycol flow is split over each contactor by means of an indicating flow meter having a manual throttle valve.

For heating the glycol, there are installed two Dowtherm vapor generators. Each of these generators has a capacity of 1,000,000 B.t.u. per hr., and is capable of maintaining the total plant heating load for a short period. The plant design, however, anticipates the use of both generators in parallel under normal conditions.

These generators are equipped with safety valves, low level warning controls, and pressure controls. The low level control is connected to sound a warning signal on low liquid level. The pressure control switch cuts off the gas to the main burners when the desired pressure is reached, but leaves the pilots burning. Upon complete gas failure, the pilot valves close, which are normally energized by an electric current generated through the heat of the pilot. The source of energy for the electric controls is a 6-volt heavy-duty storage battery. This energy source has been chosen as most reliable and is independent of power failure to the plant.

To control the base temperature of the still, there is installed a recording temperature controller having a thermo bulb in the still base. The controller operates a throttling type diaphragm valve in the Dowtherm return line to the boiler. When the reboiler must supply more heat to the still base, the valve opens and allows a greater flow of Dowtherm through the reboiler, the valve partially closing upon lower heat requirements, and thus flooding part of the reboiler surface with liquid.

The source of electric power is 440-volt 60-cycle alternating current, which is purchased from the Coastal plant of The Chicago Corporation situated nearby. The generated power is transformed from 440 volt at the plant to 2300 volts at which voltage it is transmitted to the dehydration plant, where it is stepped



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Naturally we are proud that Horn Paints and Technical Coatings were selected and used on all the station and storage tanks on this great pipe line. The successful completion of this outstanding project reflects the highest credit on all executives, engineers, purchasing agents—all men, both supervisors and workers who have worked together in such effective cooperation.

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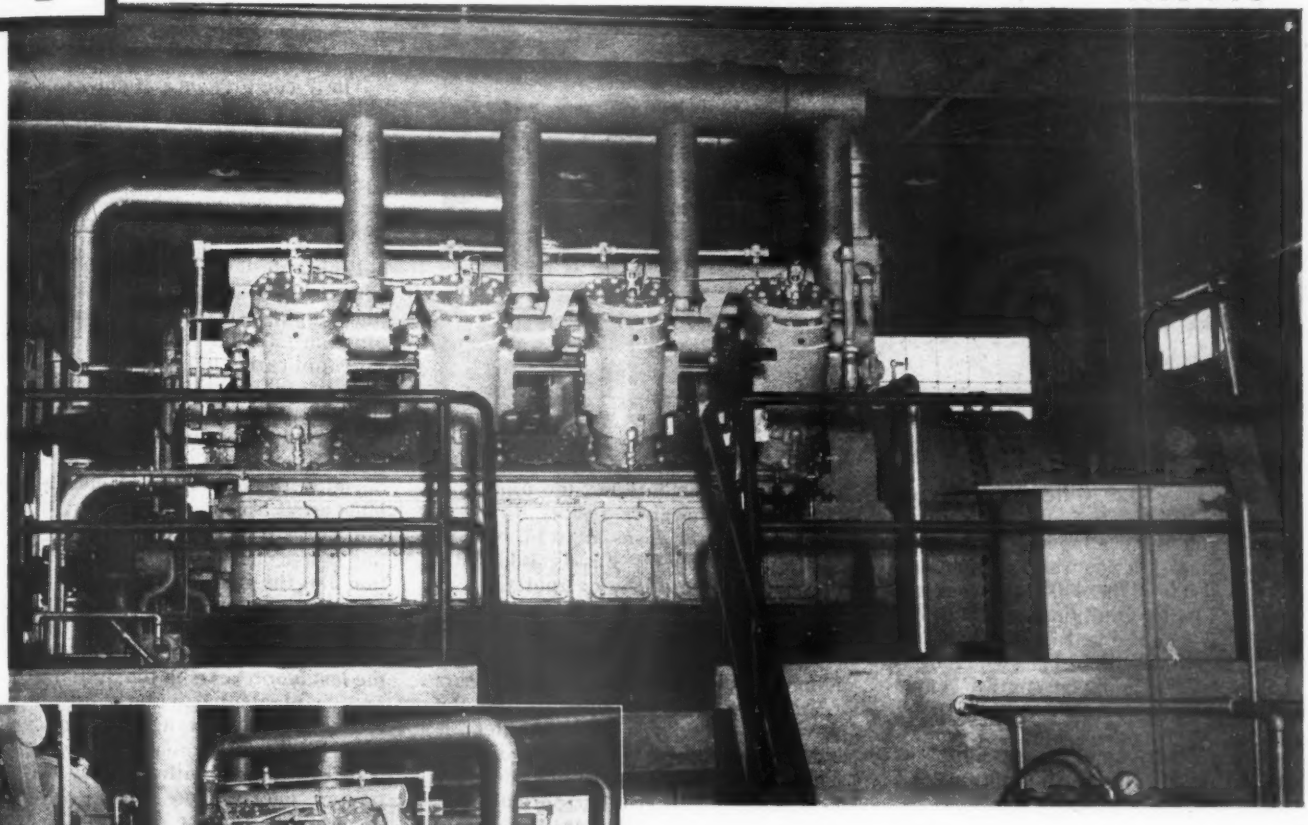
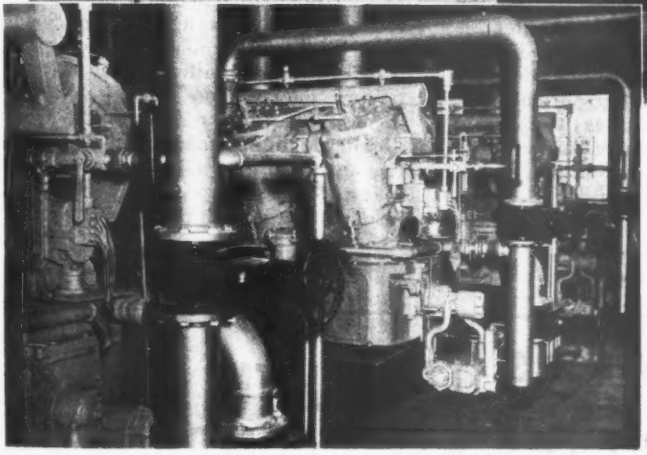
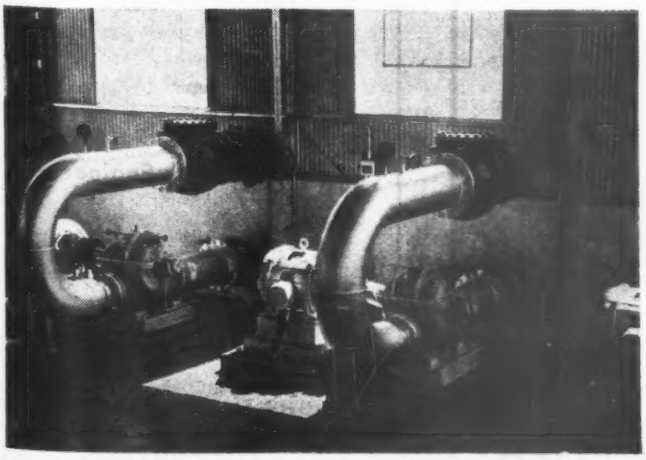




The Batesville station—one of four, in each of which are installed three PVG engines.



Ingersoll-Rand Cameron centrifugal circulating water pumps serve many stations on the Tennessee Gas & Transmission Line.

Serve the Tennessee Gas & Transmission Line

A number of the big stations of the great new line of the Tennessee Gas and Transmission Company are served by generators driven by Ingersoll-Rand 4-cycle Type PVG gas engines. Each installation has three 8-cylinder, 370 horsepower engines direct-connected to alternating current generators.

Gas engines of this type have established an enviable reputation in all divisions of the petroleum industry—pipelines, refineries, repressuring, recycling, and gasoline plants—driving generators, pumps, blowers, etc. Size 185 to 1200 BHP.

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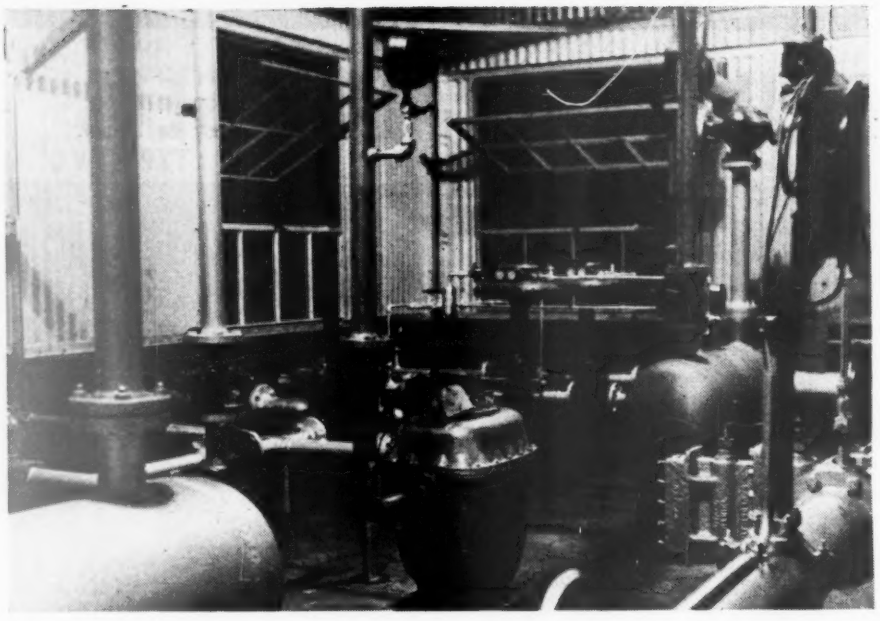

Interior of meter building at Batesville, Mississippi.

down again to 440 volts. This voltage transformation results in saving approximately 4700 lb. of copper and is a less expensive installation than a complete 440-volt system. The 440-volt power enters the boiler building switchboard where it is metered and is distributed to the points of utilization. The switchboard is a completely unitized control center of the totally enclosed type.

A recording calorimeter and gravitometer are housed in a specially constructed room of the office building. The room has fully insulated walls and ceilings and double windows. Doors giving entrance to the room slide rather than swing, thus creating less air disturbance. The calorimeter is used to determine and record permanently in B.t.u. the calorific value of the gas entering the pipe line. The instrument gives results direct in B.t.u. per cu. ft. of gas at 30 in. of mercury pressure and 60° F. saturated, without manual operation, computation, or correction of any kind.

The recording gravitometer gives an accurate permanent record of the gas going into the pipe line. For many years it was the common practice to test the gravity of gas sold at periodic intervals and use the value obtained to predict the orifice coefficient for orifice delivery meters for the ensuing period. The changing gravity requires a constant record in order to make an accurate measurement of the gas, and this instrument provides such a record.

All fuel used in the operation of the dehydration plant is metered through a dual installation of displacement meters and regulators, adequately safeguarded by pressure relief valves.

COMPRESSOR STATIONS

The 7 compressor stations are not all alike either in horsepower or equipment, and as the flows of gas, cooling water, etc., are traced through the station, the equipment in various stations will be mentioned. A typical compressor station flow sheet is given on Page 154.

▸ **Piping design.** The engineers responsible for the design of the compressor plant piping have felt that cross-country pipe-line standards are inadequate for safe application to piping in such plants, even though the above section and division of the code permits carrying the cross-country piping standards into the compressor, provided such stations are outside cities or villages or closely populated areas. Instead of following this section of the code, it was decided to follow the much more rigid standards of section 3 of the same code, using the standard set up in this section for oil and gas piping inside refinery limits. Extensive use of this latter section of the code over the last 5 or 6 years in the design of compressor plants, particularly for unusually high pressures ranging from 2500 to 4000 lb., has indicated that the heavier wall thicknesses called for by this section are necessary in order to withstand the additional stresses imposed by vibration in the piping immediately surrounding the compressors themselves. This standard was accurately followed throughout the high pressure gas piping

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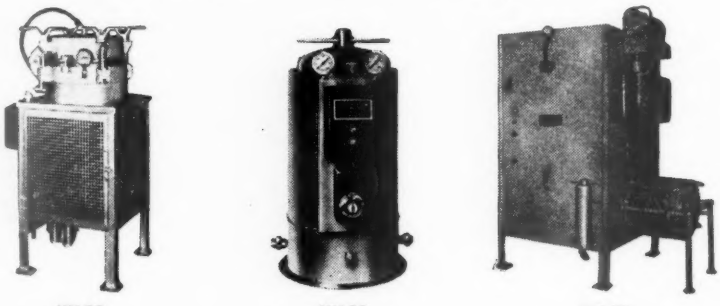

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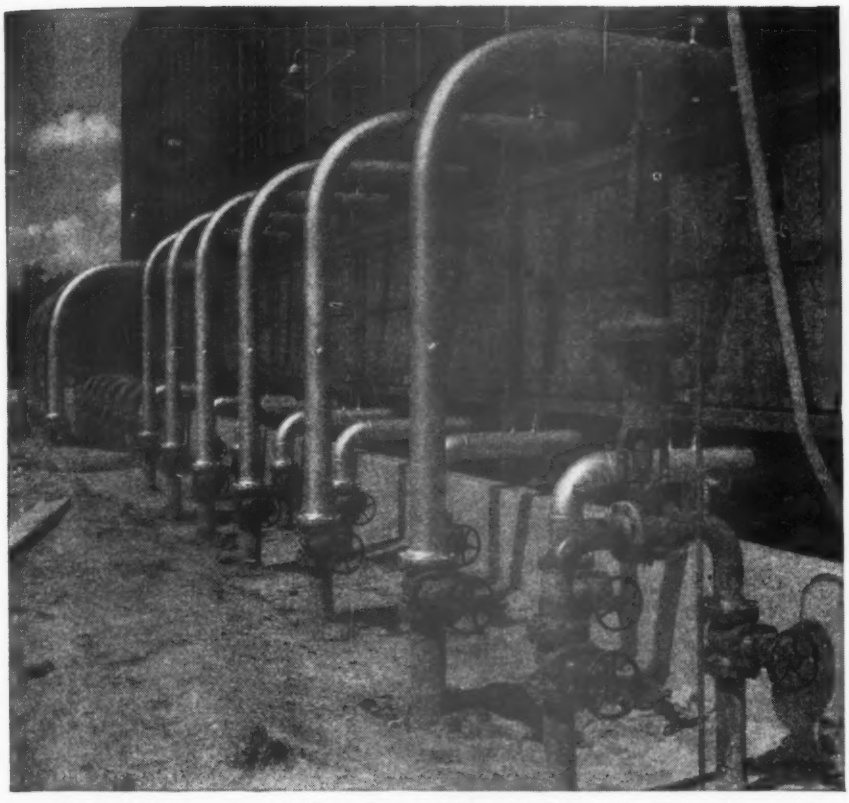
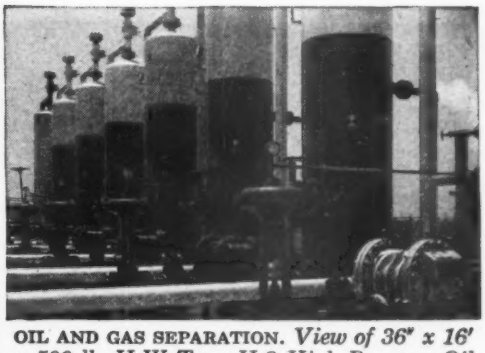
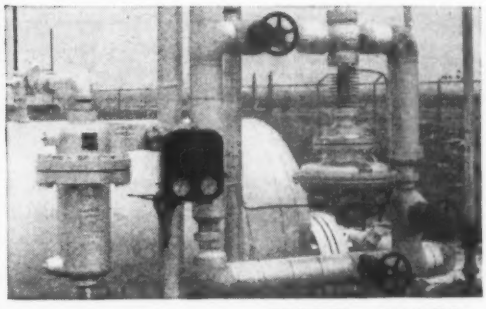


HOMEFRONT PIPE LINE. Hanlon-Waters Type 1500 Butterfly Valve controlling water to cooling tower on new **Tennessee Gas and Transmission Co.** pipe line from Corpus Christi, Texas to Cornwall Station, West Virginia—one of many H-W controls used in this project.



OIL AND GAS SEPARATION. *View of 36" x 16' x 500 lb. H-W Type H-2 High Pressure Oil and Gas Separator Metering Installation.*



LIQUID LEVEL CONTROL. *H-W Type 850 Displacement Level Controller Torsion Tube Assembly on Stabilizer Reboiler. Type 850 controls liquids of any gravity, temperature or working pressure.*

Controlling CONTROL PROBLEMS of the Oil Industry

BATTLEFRONT PIPE LINE. American armies now supply oil and gasoline to advancing motorized units through portable pipe lines—laid by unskilled men at the rate of 60 to 70 miles per day—faster than fighting units can advance. (Hanlon-Waters, prime contractor.) Controls make the "on-off" action of the line pumping stations automatic.

WAR BROUGHT new, large-scale problems to the oil industry. Transportation was one of them. Pipe lines replaced tankers. Successful continuous operation of pipe lines depended on controls.

War-production of styrene, butadiene, toluol and high octane gasoline demanded new precision controls to meet extreme and exacting requirements of large-scale processing.

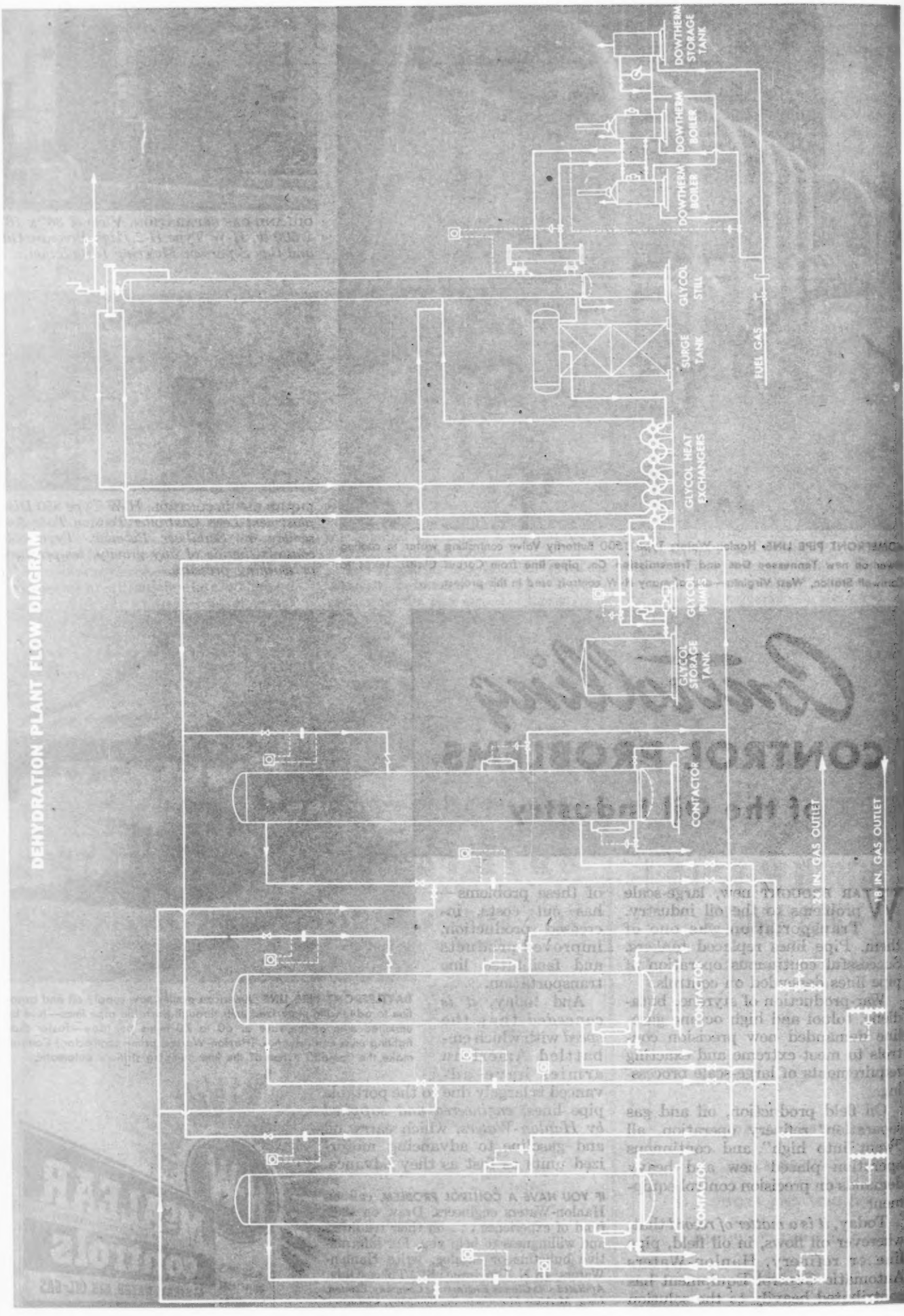
Oil field production, oil and gas separation, refinery operation, all "went into high" and continuous operation placed new and heavy demands on precision control equipment.

Today, *it is a matter of record* that, wherever oil flows, in oil field, pipe line or refinery, Hanlon-Waters Automatic Control Equipment has contributed heavily to the solution of these problems—has cut costs, increased production, improved products and facilitated line transportation.

And today, *it is conceded* that the *speed* with which embattled American armies have advanced is largely due to the portable pipe lines, *engineered and supplied by Hanlon-Waters*, which carry oil and gasoline to advancing motorized units as fast as they advance.

IF YOU HAVE A CONTROL PROBLEM, call on Hanlon-Waters engineers. Draw on their fund of experience . . . on their readiness and willingness to help you. For informative bulletins or catalog, write Hanlon-Waters, 15 N. Cincinnati St., Tulsa, Okla.

Affiliated with Climax Engineering Company, Clinton, Iowa; McAlear Manufacturing Company, Chicago.



DEHYDRATION PLANT FLOW DIAGRAM

from the plant side of the inlet scrubber to the inlet flanges of the gas aftercoolers. A compromise standard roughly half way between the thicknesses called for under sections 2 and 3 was selected for piping beyond these points for a distance of approximately 150 yards each side of the compressor stations. It is felt that this additional safety factor in the piping close to the compressor stations is well justified on account of the concentrated risk to equipment and personnel represented by an operating station.

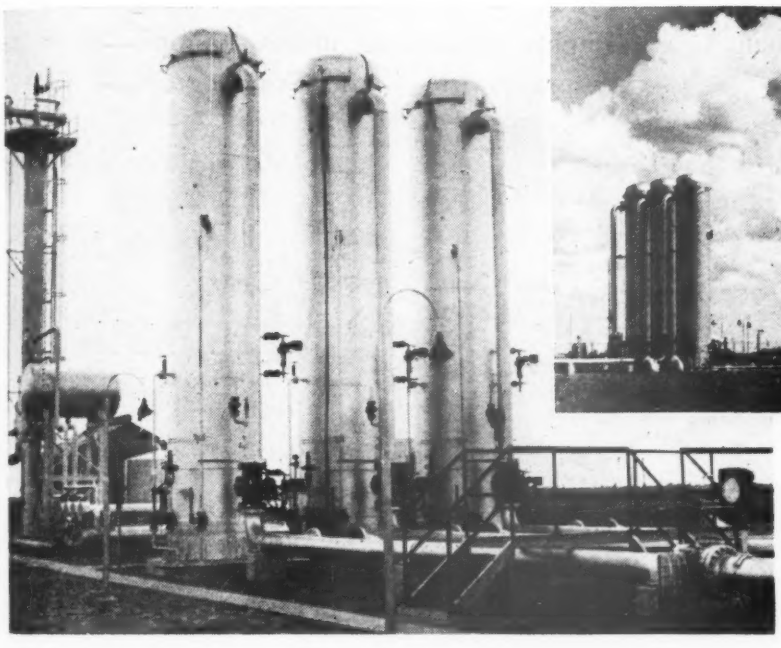
Dust scrubbers. The inlet gas to the station is piped through 24 in. pipe to a battery of dust scrubbers. Three of these scrubbers are installed in all stations at present. At ultimate gas flow all stations, except No. 14, will require four. No. 14, on account of the subtraction of fuel gas, requires only three. These scrubbers are 5 ft. in diam. and have a net shell length of 20 ft. Each vessel is designed according to the API-ASME code for pressure of 786 lb. at a temperature of 100° F.

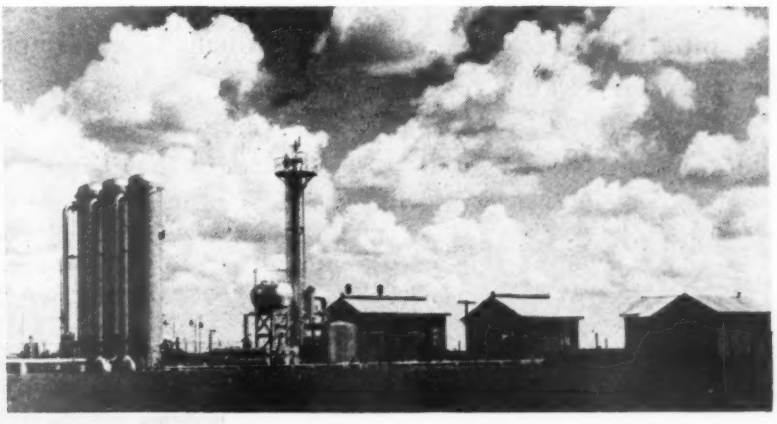
Each scrubber is designed to have a capacity of 75,000,000 cu. ft. per 24 hr. of gas. There is a 12-in. bypass around these units to permit taking one unit off the line in an emergency.

The scrubber oil settling tanks and scrubber oil charging tank are mounted on a steel framework. The dirty oil blown from the base of the scrubbers enters directly into either one of two 5 ft. by 5 ft. tanks, where the dirt is allowed to settle from the oil. The oil, after the dirt has settled, is drawn off through a swing suction line to the scrubber oil charging tank. A 3-in. line with shut-off valve is provided from the bottom of each tank. This is designed to drain the accumulated dirt and settlings to be placed into suitable containers for disposal, road surfacing, etc.

The vents, hatchways, etc., in these scrubber oil settling tanks are made completely weatherproof. This was necessary to prevent moisture from entering the oil, carrying over to contaminate the dehydrated gas.

For filling the charging tank, a 14 gal. per min. herringbone gear type pump,

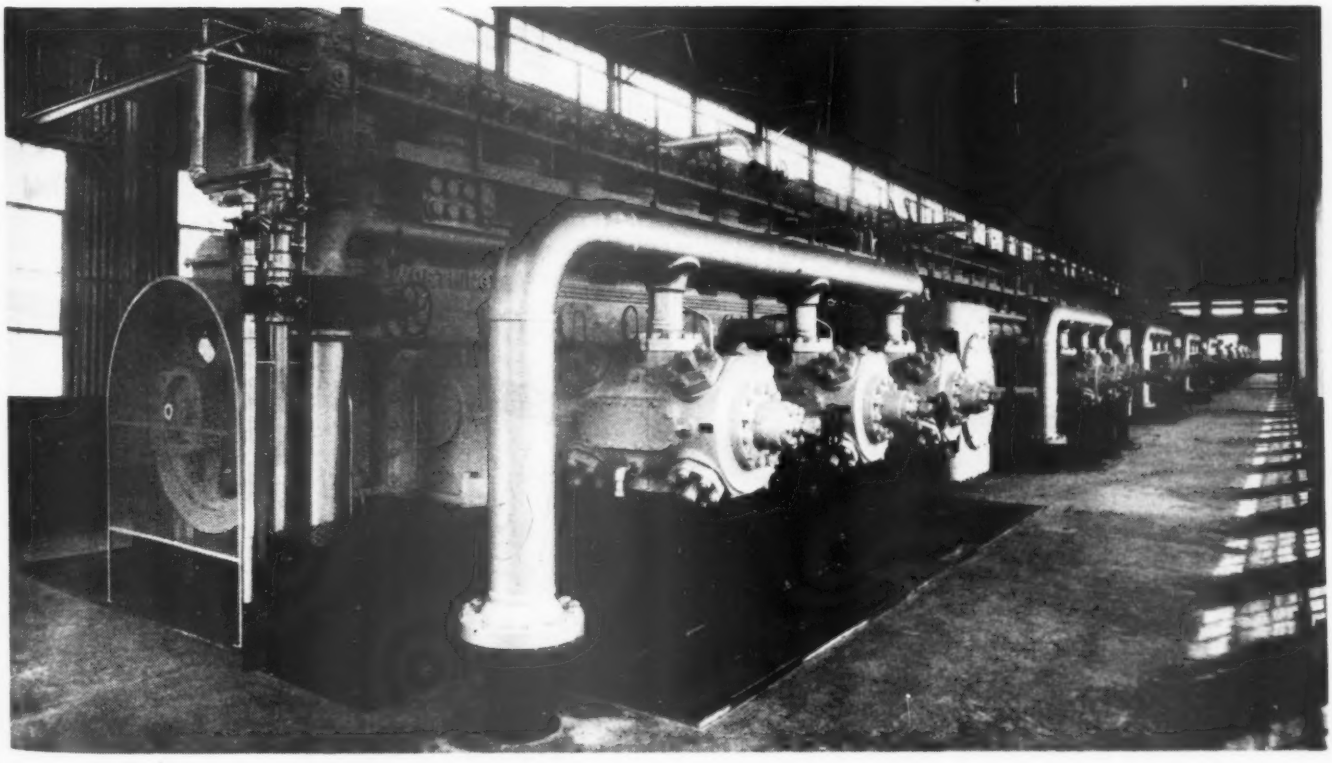




General view, dehydration plant.

Contactors, dehydration plant, Aqua Dulce, Texas.

Interior of compressor building.



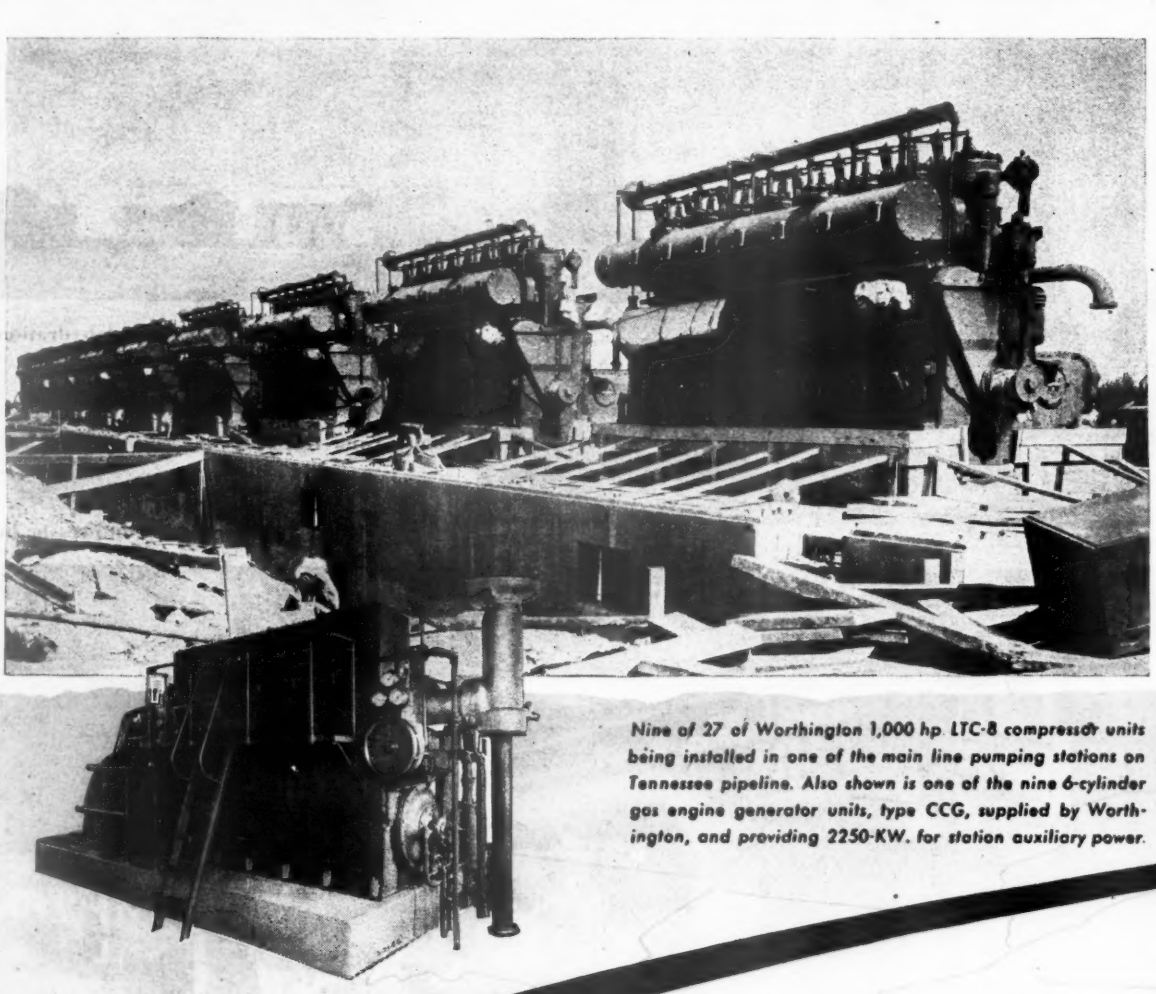
ON THE BIGGEST GAS

Tennessee Gas and Transmission Company Selects Worthington Engine-

WORTHINGTON Angle Engine Compressors—27 of them, totaling 27,000 hp.—are pumping war-essential gas from Texas to Mississippi, through approximately 50% of the big pipe that stretches across the continent to West Virginia.

But Tennessee Gas and Transmission Company, in pushing forward this biggest gas pipeline job in a decade, came to Worthington for more than compressors alone.

Engine generating units — pumps — other accessories — all Worthington —



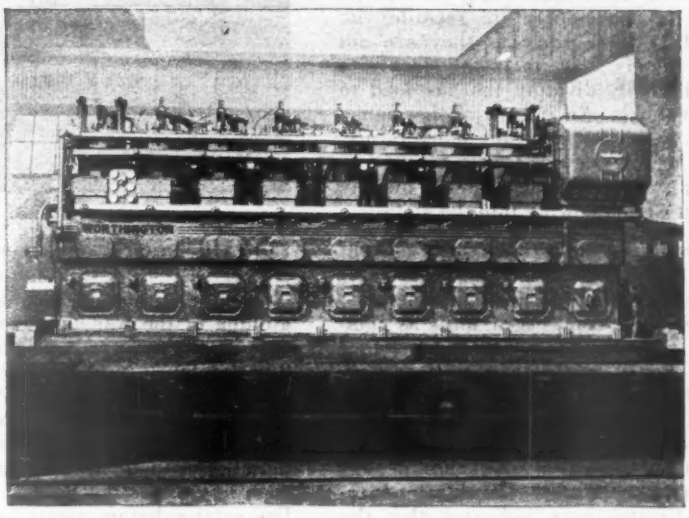
Nine of 27 of Worthington 1,000 hp. LTC-8 compressor units being installed in one of the main line pumping stations on Tennessee pipeline. Also shown is one of the nine 6-cylinder gas engine generator units, type CCG, supplied by Worthington, and providing 2250-KW. for station auxiliary power.

PIPELINE JOB SINCE '32

Compressors, Generating Units and Pumps for Main Line Pumping Stations

were supplied from a single source, engineered together as complete units for highest efficiency.

Another construction victory in Tennessee Gas and Transmission Company's win-the-war effort. Another example, too, of Worthington's pipeline "know-how" and broad range of products for gas and oil transmission now at work for Industry and the Nation. Write us for complete details. *Worthington Pump and Machinery Corporation, Engine Division, Buffalo, New York.*



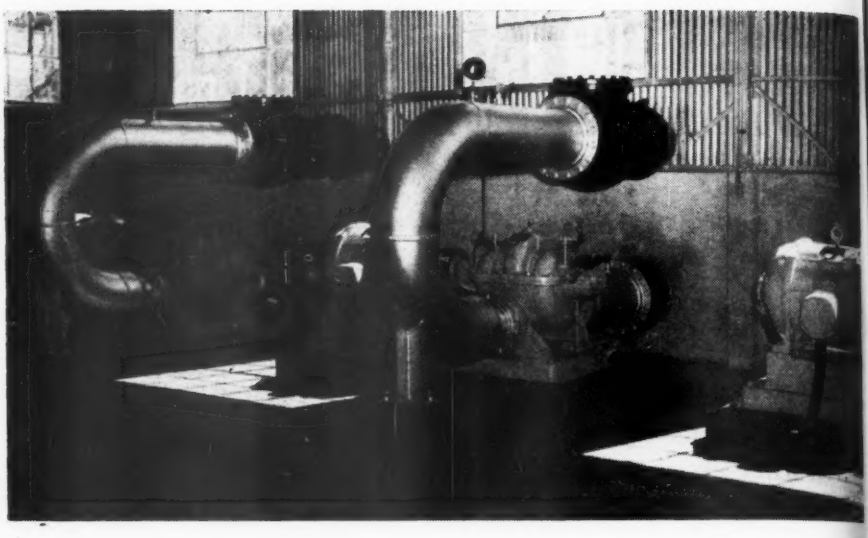
A Worthington 1,000 hp LTC Gas Engine Compressor ready for shipment.

5 Reasons Leading Companies Specify Worthington for Pipeline Units

1. **Heavy Construction**—ample masses of metal in correct structural relation, for strength, rigidity, maintained alignment, low maintenance, long life.
2. **Straight-Line Design**—maximum accessibility for simple, safe inspection and adjustment. Smooth power flow from equally spaced power impulses.
3. **Single Scavenging Air Pump**—easily accessible for maintenance, with simple piping for low-cost installation
4. **Cone-type Cylinder Head**—bolt-loading on cold upper surface, no risk of cracking when tightened, no bending under heat stress, cuts engine repair cost.
5. **Cast-In Lube Oil Ducts**—all lube oil in cast-in passages ends risk of pipe breakage, with no joints or pipes to break or loosen.

YOUR PARTNER IN POWER PROGRESS

BEHIND THE NAME WORTHINGTON



Motor-driven jacket water circulating pumps.

with built-in safety valve, is provided. This pump is so manifolded that it takes suction from the lower half of either scrubber oil settling tank and discharges into the filling tank.

The gas leaving each scrubber passes through a vertical section of 12-in. pipe that serves as a meter run. This run is connected to a recording flowmeter. There is no temperature recorder installed at these runs, as they are not check meters, but are installed only to permit evenly dividing the gas load to the scrubbers. An industrial thermometer in each run indicates temperature. These meters, however, may be used to give an approximate check on the amount of gas flowing into the station.

▸ **Selection of compressors.** On account of the lower weight per horsepower of the modern high speed angle type gas-engine-driven compressor units as compared with the slow speed horizontal types, the War Production Board required that the high speed machines should be used. It is the opinion of the writers that this decision might have been made anyway without the interference of war conditions. Careful comparative estimates have indicated that the slow speed horizontal compressor units, which have been used conventionally in the past on pipe-line service, cost from $5 to $10 more per horsepower on an installed basis than the high speed angle type units. In many cases up to the beginning of the war emergency the slow speed units have been preferred despite this difference in installed cost because operating data indicated lower maintenance cost. It is believed that this opinion was often based on insufficient experience with the angle type units, for such units were not used at all in pipeline service before about 1937. Further experience with the angle type units has given increased evidence that the maintenance costs are little, if any, higher than for the slow speed units, and consequently, there is a tendency to prefer the high speed units for all types of service. It is felt that this question cannot finally be settled until more experience with the high speed units has been accumulated.

▸ **Compressors.** At each of stations 2, 4, and 6 are presently installed nine 1000-hp. in-line angle type gas-engine-driven gas compressors. These machines are placed end-to-end in a 30 ft. by 304 ft. steel frame, corrugated galvanized iron covered building, having a full ridge

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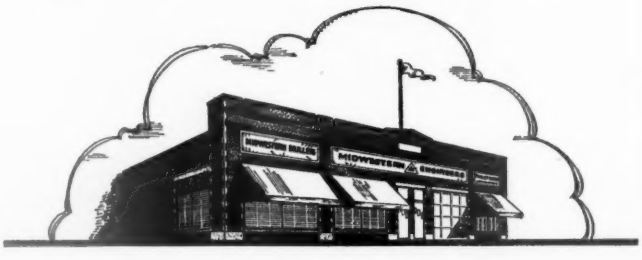
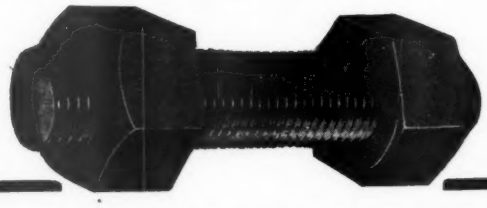


Standco
PRECISION BOLTS

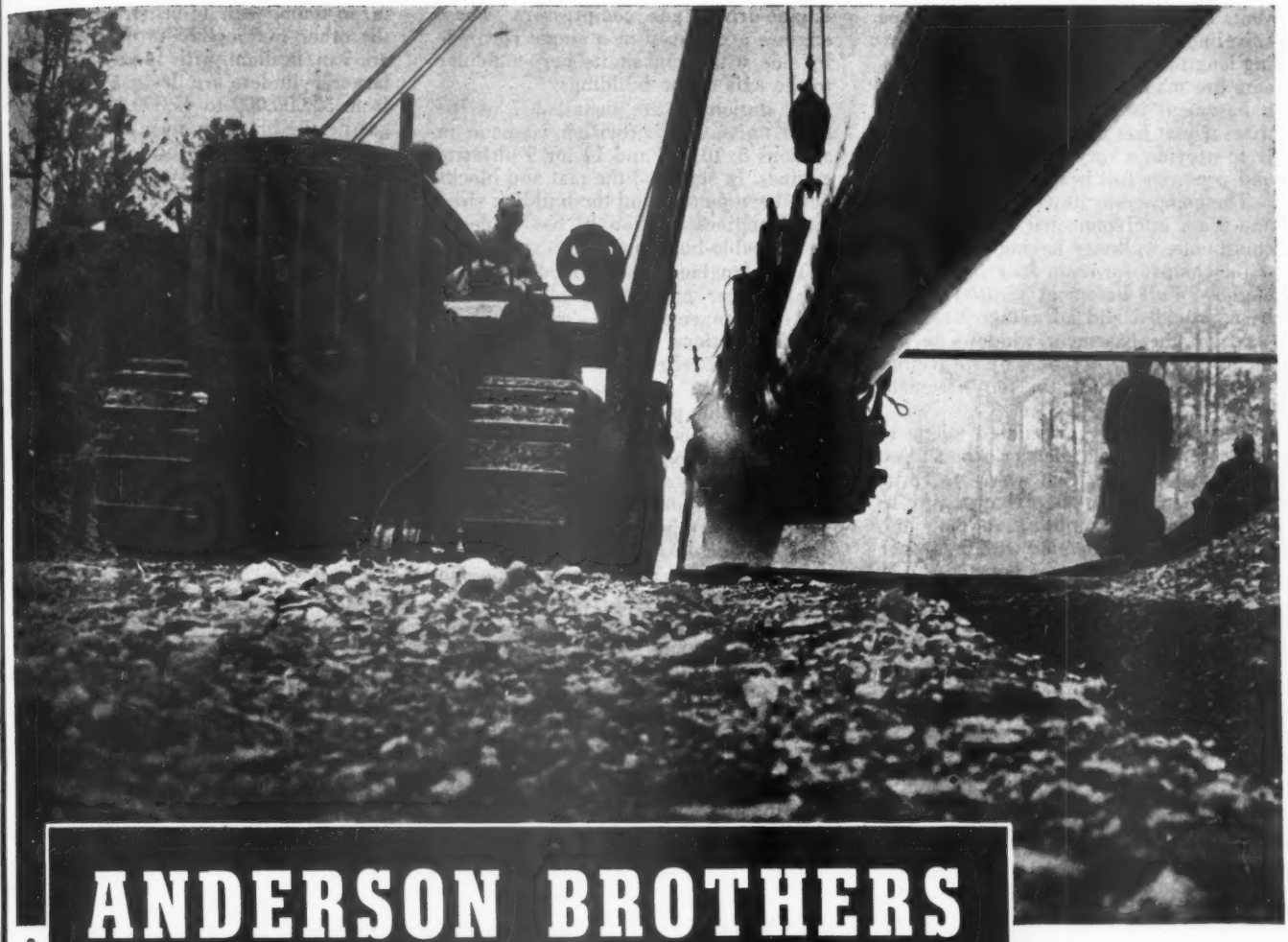
OUR CONGRATULATIONS TO

TENNESSEE GAS & TRANSMISSION CO.
on a Big Job Well Done

Standco specifications—high tensile alloy steels—modern heat treatment—precision manufacturing methods—those were the reasons for the use of Standco Precision Bolts on the Tennessee Gas pipe line. We appreciate the compliment.



STANDCO BOLT CO.
2701 CLINTON DRIVE
HOUSTON, TEXAS



ANDERSON BROTHERS
furnishes equipment for construction of
TENNESSEE GAS TRANSMISSION LINE

Construction of the 24-inch T-G-T gas line required much specialized and extra heavy equipment. During our many years of pipe line construction, we have assembled a large amount of standard and specialized contractors equipment, which we placed at the disposal of those engaged in the construction of this huge line. As a result, we were able to help materially in completing the line ahead of schedule.

These and other builders of the T-G-T gas line were furnished equipment by Anderson Brothers.

N. A. Saigh
O. C. Whitaker
Brown & Root, Inc.

Joe R. Horrigan
Mid-Western Engineers & Contractors
Pittsburgh-Des Moines Steel Co.

ANDERSON BROTHERS

PIPE LINE CONTRACTORS

503 Nat'l Bank of Tulsa Bldg.
Tulsa, Oklahoma

707 N. Drennan Street
Houston, Texas

Oil City,
Pennsylvania

vent. These buildings have a bridge type traveling crane operating the full building length. Foundations for the compressors are made deep in order to provide a basement in the building. The compressor mat has been designed purposely to provide a very rigid and stiff base and generous soil bearing surface.

The compressor units in stations 2, 4, and 6 are interconnected by means of a continuous walkway having steps down to the compressor room floor at alternate engines. Full basement ventilation has been provided and advantage has been taken of the basement windows to use them as safety escapes by providing access ladder rungs in the basement walls.

There are two uninsulated silencers per engine and each silencer exhaust line has a metal jacket that serves to carry heat radiated from the exhaust pipe to the outside of the building. A vent stack on this jacket is provided with a damper to enable the amount of hot air vented to be controlled. This materially reduces the building heating load in cold weather.

Air cleaners have been provided and installed on an 18-in. air intake line to all compressors. These units are provided with 16-in. backfire relief valves to prevent damage in case of backfire.

At each of stations 8, 10, and 12 are installed eight 1000-hp. V-angle type gas-engine-driven gas compressors. These engines are placed in a single row side by side with crankshafts perpendicular to the axis of the buildings.

In station 14 are installed 7 of the same units. Full provision is made in stations 8, 10, 12, and 14 for 9 ultimate engines. In station 8 the mat and blocks have been poured and the building sized for 9 engines. Station 14 has 8 blocks and suitable building.

These engines are provided with only one silencer each. Air-cooled exhaust jacket arrangements are similar to those in other stations. The same air cleaners and backfire relief valves are used.

The gas is, at present, compressed from a suction pressure of approximately 401 lb. to 750 lb. through each compressor in stations 2, 4, 6, 8, 10, and 12. In the ultimate stations, the gas will be compressed from approximately 485 lb. to 750 lb. In this case, the compression ratio will be less and the compression heating will be reduced. Compression ratios per station are shown in Table 1.

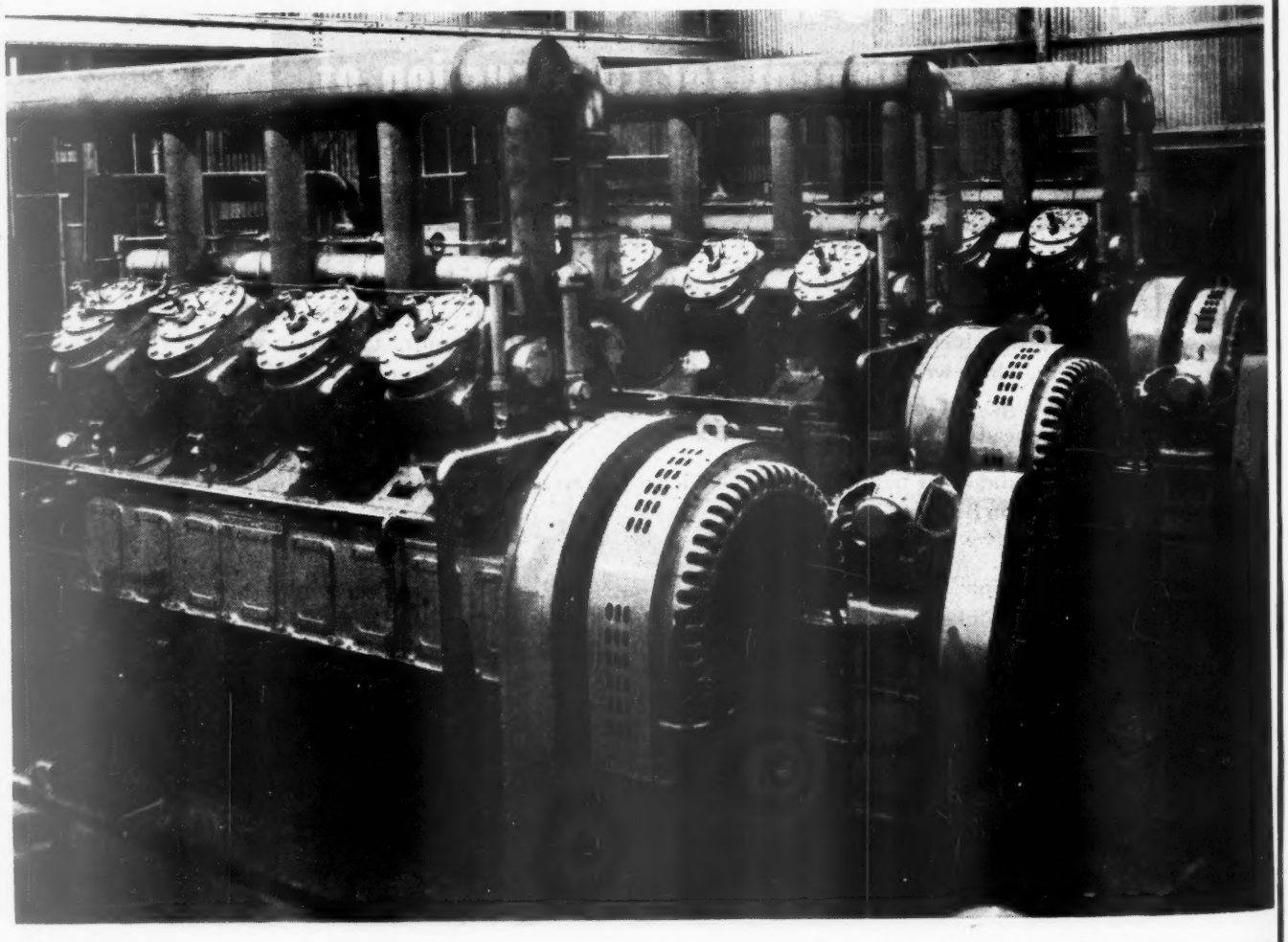
The compressor units in stations 2, 4, and 6 are provided with 3 compressor cylinders 8¼ in. in diam. with a stroke of 15 in. The compressor units in stations 8, 10, and 12 have 4 cylinders 7½ in. in diam. with 14 in. stroke. All cylinders are provided with built-in clearance pockets to provide necessary clearance for present and ultimate design.

Station 14 has been specially designed for future flexibility. Six of the seven installed engines have one cylinder 8¼ in. in diam. with 14-in. stroke, whereas the other four cylinders on these units are 7 in. in diam. with 14-in. stroke. The larger cylinders are designed to handle from 35,000,000 to 45,000,000 cu. ft. of gas per 24 hr. from an inlet pressure of approximately 400 lb. to a discharge pressure of 475 lb. for delivery to one of the sales outlets. The small cylinders handle from 150,000,000 to 165,000,000 cu. ft. per 24 hr. from the same inlet pressure with a discharge pressure up to 760 lb. for delivery to another sales outlet. The two discharge pressures are required in order to fill contractual obligations for fuel gas. The high pressure gas from station 14 is delivered through a 20-in. pipe line a distance of 82 miles to Hope Natural Gas Company, Cornwell station, and the low pressure gas is delivered 7 miles through a 12-in. pipe line to the United Fuel Company at Clendenin, West Virginia.

All cylinders in this station are equipped with unloaders, valve lifters, and built-in clearance pockets in order adequately to cover the pressure range requirements.

The gas is discharged from each compressor through a 10-in. branch line that is saddled from an expansion bend into a 24-in. discharge header.

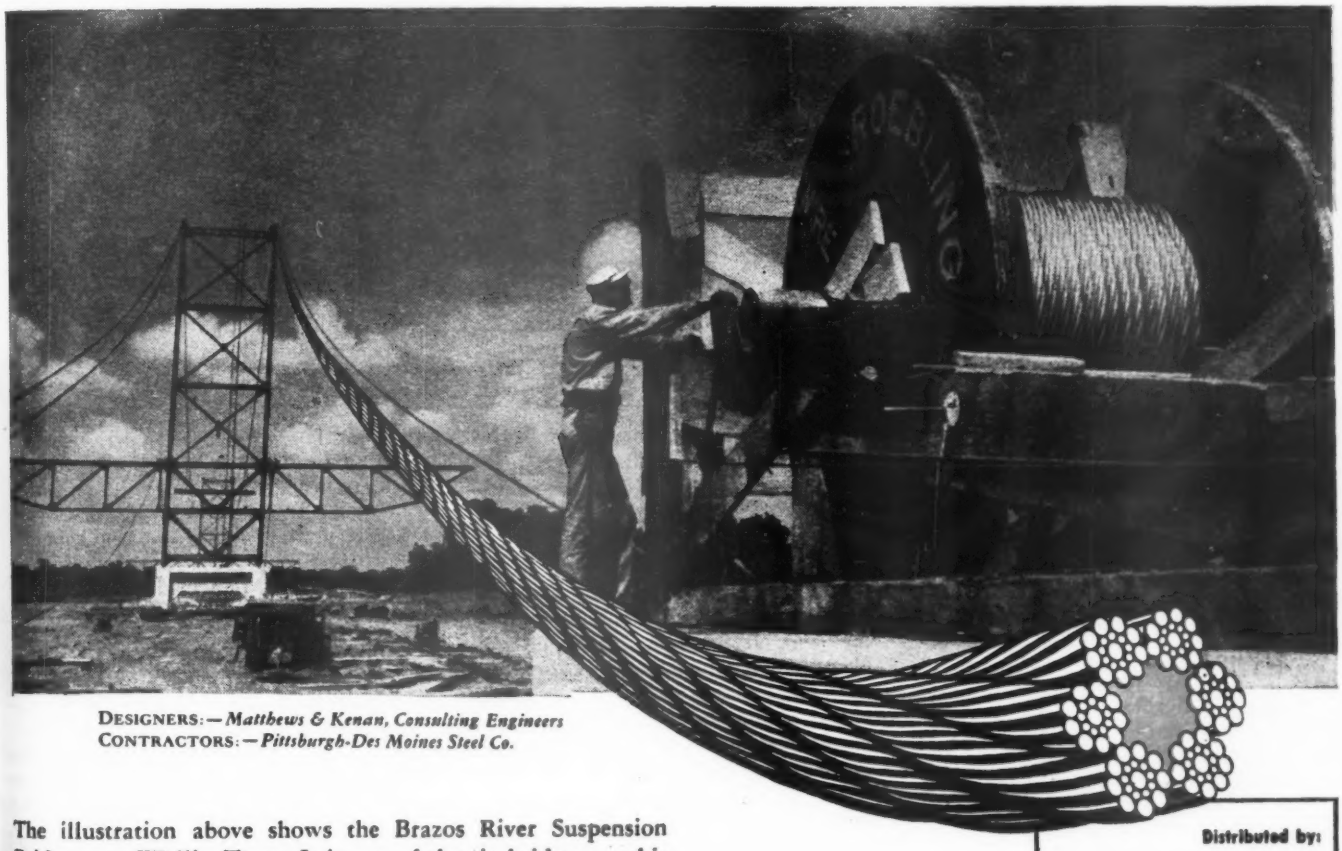
The buildings housing the engines in stations 10, 12, and 14 are 36 ft. by 202 ft. by 20 ft., and 36 ft. by 228 ft. by 20 ft. in station 8. In these stations, the compressor foundations are also deep and a full basement is provided. Full base-



Auxiliary engines.

From Texas to West Virginia... over six suspension bridges... stretches the Tennessee Gas and Transmission Company's 24-inch pipe line... 1260 miles of testimony to the high esteem held for Roebling Wire Rope by the Petroleum Industry. It's another reason why you can depend on...

ROEBLING *"Blue Center"* STEEL WIRE ROPE



DESIGNERS:—*Matthews & Kenan, Consulting Engineers*
CONTRACTORS:—*Pittsburgh-Des Moines Steel Co.*

The illustration above shows the Brazos River Suspension Bridge near Wallis, Texas. It is one of the six bridges on this new line which vary in suspended span from 560 feet to 1920 feet. All cables and suspenders and their end fittings were supplied by Roebling.

And what can *you* expect from Roebling?

Rope that has known capacity to deliver service. Engineering, in our plant and at your job, to put the rope to work right. Maintenance practices that protect its long life.

Your postwar profits and postwar jobs will depend in part on operating rope-rigged equipment at lowest cost. You can leave that part to Roebling.

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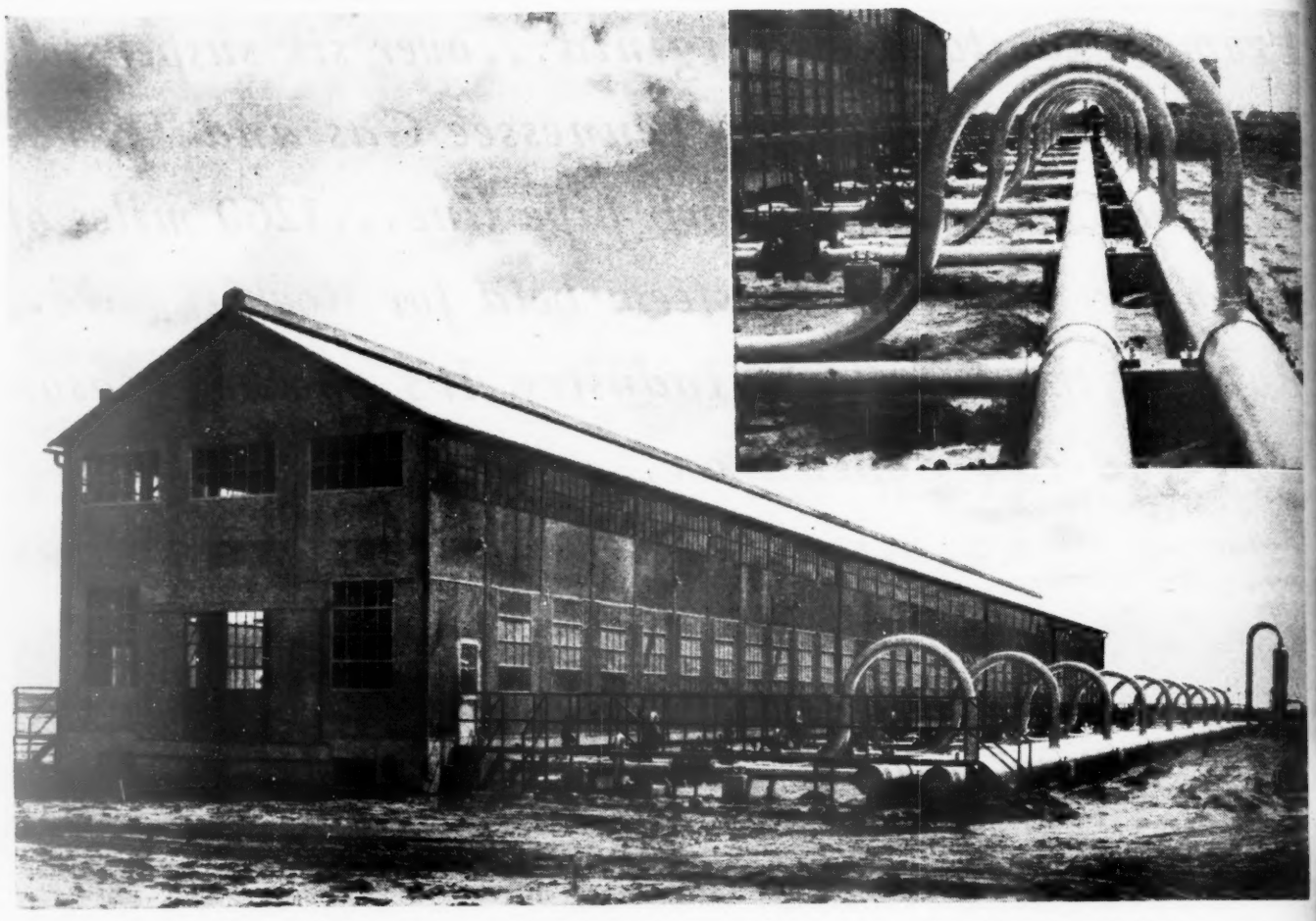


Typical compressor building with header loops in inset.

ment ventilation is also provided as in stations 2, 4, and 6.

Stairways afford access to the basement at either end of the all compressor buildings, and a central escape hatch to the compressor floor midway in the buildings affords an additional emergency exit from the basement.

Advantage is taken of the basement to house a jacket water dump tank, the oil reclaimer units, dirty and clean oil tanks, and drainage sump pumps. The jacket water dump tank serves as a container to collect jacket water drained from the engines when down for repair. Such a tank is necessary to avoid waste of expensively treated water on a closed system. The tanks are connected to enable the operator to blow, by means of air, the drained water back into the main surge tanks. These tanks are protected from overpressure.

▸ **Compressor ignition.** Engine ignition is the direct-current-impulse type with individual induction coils for each spark plug. Engines of one manufacture are provided with one distributor handling 10 cylinders. The other engines have dual ignition systems for 8 cylinders. Instead of the conventional magneto source of power to the ignition coils, there is provided an individual d-c. rectifier of the copper oxide type for each engine. These units are supplied from a 440-volt, 3-phase, 60-cycle source, having their own built-in transformers, and provide a virtually rippleless 10-14 volt, 2 to 4 amp. direct current that will supply the ignition demands of all engines. Each unit has its own volt and ampere meter, built-in circuit breaker, and rheostat for varying the voltage as required. There are no batteries in the ignition circuit.

This system of ignition was developed for the first time for this project and has been thoroughly tested under actual operating conditions by the engine manufacturers. It provides an exceptionally clean and trouble-free source of direct current.

One distinct advantage of this system is that it provides a foolproof interlock between the station electric generators, water circulating pumps, and engines. If the electric power fails for any reason, the water circulating pumps on the jacket water system, being electric-driven, necessarily shut down. As the compressor ignition system will also shut down upon power failure, the compressors are stopped at once, making it impossible for them to become overheated by running after failure of the jacket water circulation.

Another advantage is that each machine has its own individual rectifier unit and thus is independent of all the other machines. Thus the entire station cannot be shut down through failure of an element of the ignition supply, which is always a possibility where a central battery-and-charger system is used.

Finally, the system is actually cheaper to install and much cheaper to maintain than either the individual magnetos or a central battery-and-charger.

▸ **Oil system.** Two oil reclaimer units are installed in the basement at each station. These units are so arranged that the oil from any engine may be treated and returned to that engine.

An oil drain header is intalled in the basement and connected to the compressor rod packing gland housings. This header is also connected through valves to the crankcase of each engine. The compressor rod oil drips enter this line and flow to a dirty oil tank; also, when an engine is taken off the line for maintenance, the oil may be drained to the dirty oil tank. The oil reclaimer units receive oil from the dirty oil tank and deliver the reclaimed oil to the clean oil tank. A manually operated dispenser pump is placed on the compressor floor, and takes suction from the clean oil tank.

Two additional lube oil dispenser units with counters are installed in each compressor building. These pumps are directly connected to the fresh oil supply, which is stored in horizontal 10 ft. by 20 ft. main lube oil storage tank installed near the building.

There is a drain pan in the compressor floor directly connecting into the dirty oil tank, and another connecting into the clean or reclaimed oil tank. In case polluted oil must be disposed of, it may be poured down into the dirty oil tank, and clean oil may be returned to the reclaimed or clean oil tank through these drain pans. This lubrication system provides for flexibility in handling lube oil and with a minimum of waste.

Craftsmanship
in DESIGN
FABRICATION
ERECTION

Gas cooling. The 24-in. gas discharge header runs to the cooling tower, where the gas enters atmospheric cooling sections. These sections have been selected to obtain a low pressure drop, both at present and in the ultimate design. They are provided with 8-in. inlet and outlet nozzles and each bank is individually valved. The sections are connected in parallel banks of two sections each, in series, with an upward flow. In all stations, except No. 14, 800-lb. single-pass sections are used. In case of Station 14, 1000-lb. single-pass sections are used as this station is designed to operate at a higher ultimate pressure.

The main gas inlet header and each lead to and from the coils is provided with an industrial thermometer. The gas flows from the cooling sections into a 24-in. outlet header and thence directly to the main pipe line.

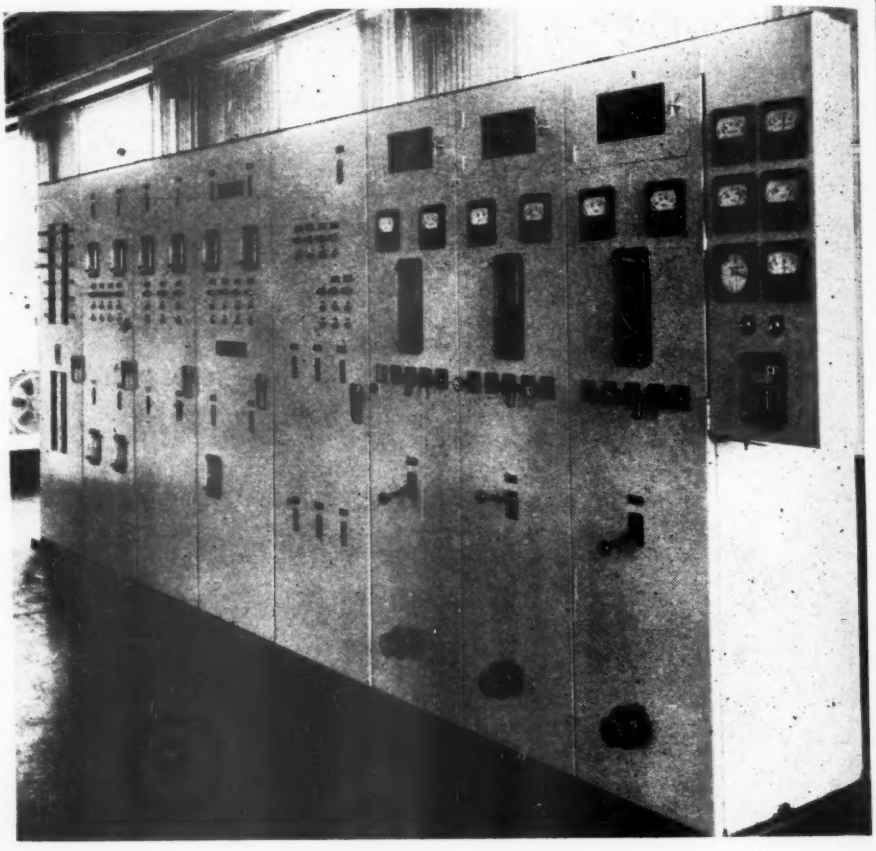
Cooling towers. The cooling towers are the induced-draft type and are all identical.

The spray water requirements for stations 2, 4, and 6 are 8000 gal. per min. each; for stations 8, 10, and 12, 8960 gal. per min. each, and for station 14, 9450 gal. per min. The design temperature of basin water for towers 2, 4, 6, and 14 is 93°F., and for towers 8, 10, and 12 is 92°F. The water is cooled to 80° in these towers with 75°F. atmospheric wet bulb, except No. 14, which cools the water to 81° with 75° wet bulb.

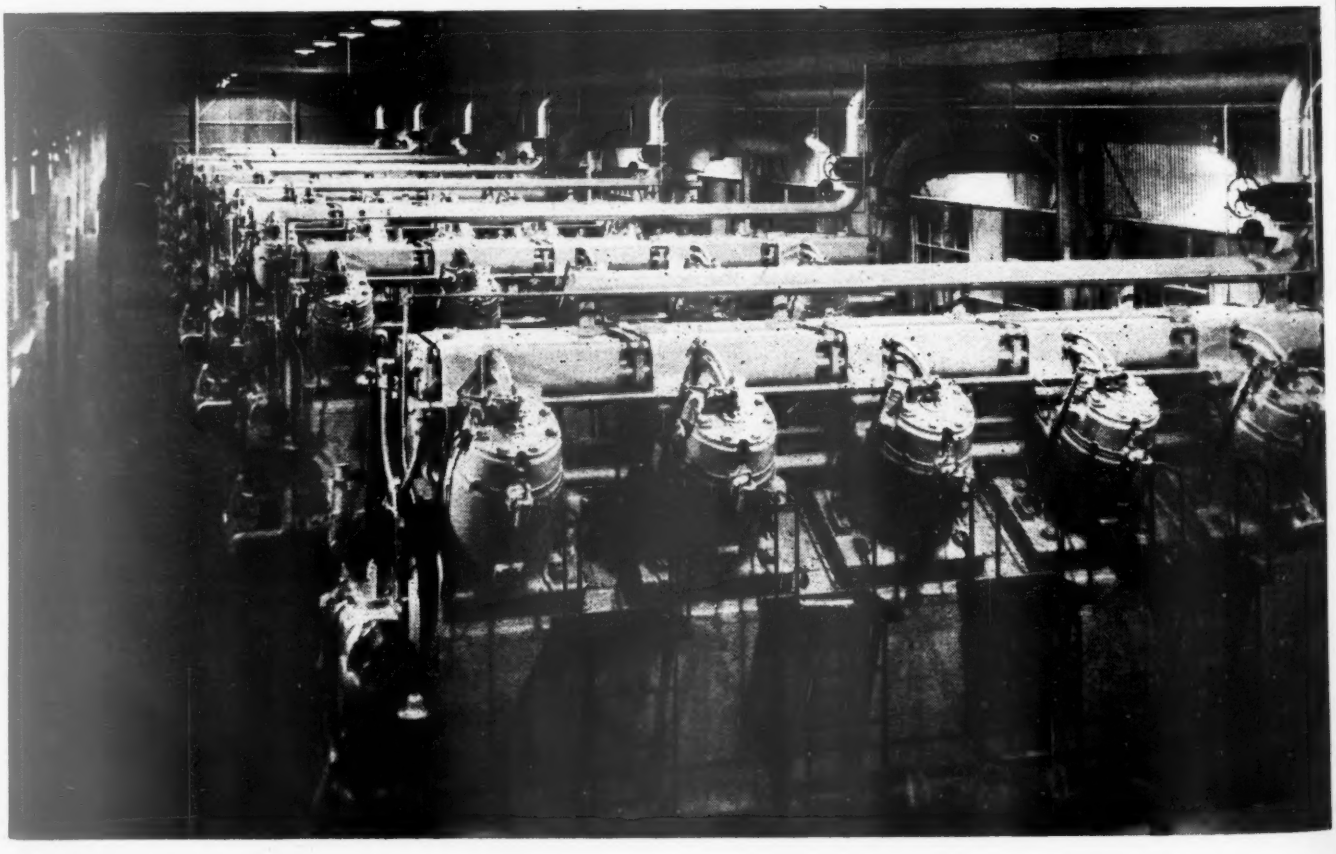
Three pumps have been installed per tower for recirculating the spray water. They are vertical, single stage, turbine type pumps, electric motor driven. In stations 2, 4, and 6, each of these pumps handles 4000 gal. per min.; in stations 8, 10, and 12, 4500 gal. per min. each, and in station 14, 4750 gal. per min. each.

The pumps are mounted at one end of the tower, over a sump that communicates through double screens with the basin proper. Each pump discharges through an 18-in. check and gate valve into a 24-in. header line. Water is taken over the tower through three 16-in. lines. Each of these lines has orifice flanges and plate installed in order that the water may be metered.

Cooling water is made up to the tower



Right, typical switchboard; below, interior of compressor building.



through a 4-in. line. After much discussion, makeup water valves were discarded and 4-in. meter runs were installed. An indicating flowmeter is installed to control the water flow to the tower. This provides an accurate method of maintaining control over makeup and assures a constant wastage, thus controlling the basin concentration of salts.

Cooling water system. In selecting the proper cooling system, the principal objective was to attain a cooling system that would permit of not more than 10°F. temperature rise through the power cylinder jackets, and with a minimum power consumption. All manufacturers contacted agreed that a 10°F. rise through the jackets of the engines was desirable for best engine performance.

The system chosen and installed calls for two separate cooling water systems.

The "hot" circuit circulates water through compressor engine cylinder jackets and electric generator engine cylinder jackets in parallel, and thence through cooling sections mounted in the cooling tower. The entering water is at 140°F. and the temperature rise is 10°F. The water is circulated at stations 2, 4, and 6 by means of 2 electric motor-driven horizontal single-stage centrifugal pumps each having a capacity of 3600 gal. per min. A 10 ft. by 20 ft. vertical surge tank is provided on the suction of the pumps. Two units are required for normal operation, and a third unit is provided for a spare.

As stations 8, 10, 12, and 14 have been calculated to handle a total future installation of 9 engines, the same size cooling water pumps have been installed as in the other stations.

As two of these units run continuously, no emergency control has been provided on these pumps. If one pump should shut down, the second pump will maintain sufficient circulation to prevent damage until the spare pump can be started, or the compressors and generators shut down. A pressure switch is installed on the pump discharge that sounds a warning signal on low pressure or pressure failure.

The pumps force the jacket water through a 24-in. header to the cooling tower, where it flows upward through 6 parallel banks of 2 atmospheric cooling sections in all stations, except No. 14, which has five. These coils have 8-in. inlet and outlet nozzles, and require a 6-lb. pressure drop. Industrial thermometer wells are installed in each inlet and outlet line.

To control the cooling water temperature, a temperature-controlled bypass valve is connected across the inlet and outlet water headers. The outlet water temperature from the engines is controlled.

In the secondary or "cold" circuit, the water passes through the oil coolers and the compressor cylinders in series. The water from the compressor cylinders flows to a 4 ft. diam. by 20 ft. high surge and vent tank connected in the circuit and merges with the water from the generator oil coolers at the suction of the recirculating pumps. The pumps discharge the water through a 14-in. header to the cooling tower, and through 6 parallel cooling banks each consisting of 2 sections in series at stations 2, 4, 6, and 14, and 7 parallel cooling banks each consisting of 2 sections in stations 8, 10, and 12.

Water circulation in the "cold" circuit is maintained at stations 2, 4, and 6 by use of an electric motor-driven, horizontal double-suction single-stage centrifugal pump having a capacity of 1335 gal. per min. At stations 8, 10, 12, and 14 this pump is rated 1850 gal. per min. Spares are provided for all pumps.

In this system, one pump runs continuously and one pump acts as spare. No automatic starting system for the spare pump has been installed, for a failure of cooling in this system will do no damage. To control the temperature in the cold circuit, a temperature-controlled bypass valve is connected across the inlet and outlet headers to the cooling sections.

All water in the cooling systems is treated for corrosion control and to reduce scale forming tendencies. The cooling tower basin and piping alone contain approximately 175,000 gal. of water; the "hot" circuit contains about 45,000 gal., and the "cold" circuit about 15,000 gal. Before initial operation of these systems, each was given a treatment to obtain the best possible cooling water. It is planned to make daily checks

(Continued on Page 176)

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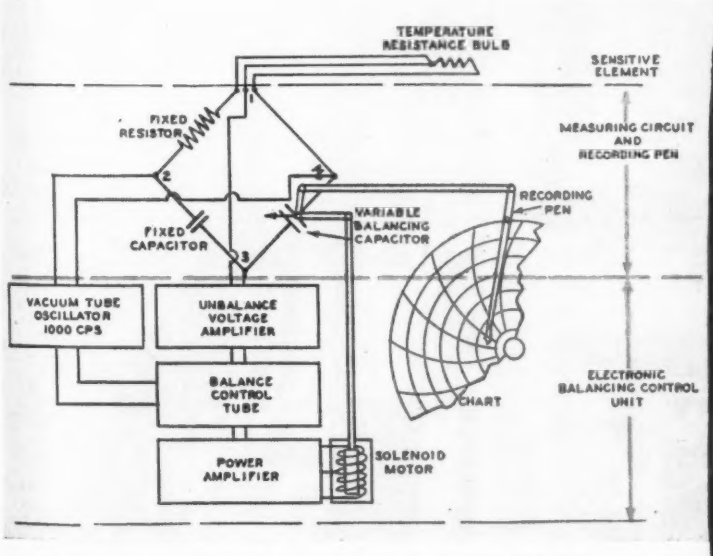
Mechanical Simplicity of the *DYNALOG* Instruments is clearly shown by the illustration opposite. A variable balancing capacitor is used to eliminate sliding contact and slide wire cleaning problems. A push-pull magnetic balancing drive motor eliminates bearings and gear trains with their periodic maintenance and possible failure.

Performance of *DYNALOG* Instruments is higher than ever available before: (1) dynamic balancing without overshoot or hunting – 3 seconds for full scale pen travel; (2) high sensitivity – definite balancing action on unbalance voltages under 15 microvolts; (3) calibration accuracy ¼ of 1% of scale span; (4) accurate recording of highly expanded scales; (5) continuous drive and "live" balance with high power at bridge null-point.

On any problem demanding such unprecedented performance, call in a Foxboro engineer. *DYNALOG* Temperature Recorders and Multiple-Point Indicators are available for 8-week delivery on AA1 rating. **The Foxboro Company, 130 Neponset Avenue, Foxboro, Massachusetts, U. S. A.** Branches in principal cities.



Schematic diagram and interior view of a *DYNALOG* Recorder. In both, the broken green line indicates where the electronic circuits join the measuring and recording unit to form the single, integrated *DYNALOG* system.

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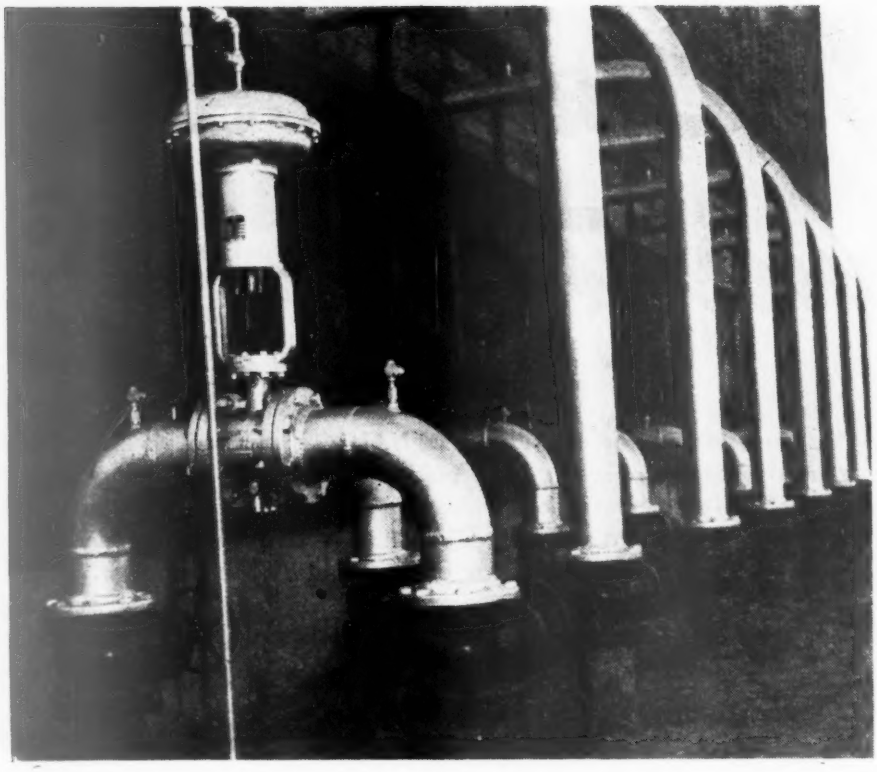


pit at one end of the building and are reached by stairs.

In all stations the starting air units consist of 1 electric driven air compressor and 1 combination electric motor and gasoline engine drive air compressor. All air compressors have a 40 cu. ft. air per min. capacity so that each station has a total capacity of 80 cu. ft. per min. These compressors discharge into four 30 in. by 15 ft. air receivers designed to operate at 250 lb. The air tanks have pressure gauges and relief valves.

A small oil reclaimer unit is installed in each generator building, and operates on the 3 engines. A dirty oil tank is provided to allow crankcase oil from any engine to be drained. The reclaimer unit takes oil from this tank, cleans it, and discharges it into a clean or reclaimed oil tank provided with a dispenser pump. Oil makeup may be from this tank or from another dispenser pump connected to the 10 ft. by 20 ft. main lube oil storage tank.

▸ **Water supply and storage.** In stations 2, 4, 6, and 8 two water wells each supplying 200 gal. per min. have been drill-

Temperature control on jacket water surge tank, Batesville, Mississippi. Below, air filters and silencers, Monroe, Louisiana.

(Continued from Page 173)

on all water to insure complete water control, which control will be directly reflected in reduced maintenance costs and increased pumping capacities by maintaining high heat transfer coefficients.

▸ **Electric power system.** Electric power for each compressor station is generated by 3 gas engine-driven generators. In stations 2, 4, and 6, the 4-cycle gas engine drives are rated 400 hp. at 450 r.p.m., and in stations 8, 10, 12, and 14 the units are rated 370 hp. at 400 r.p.m.

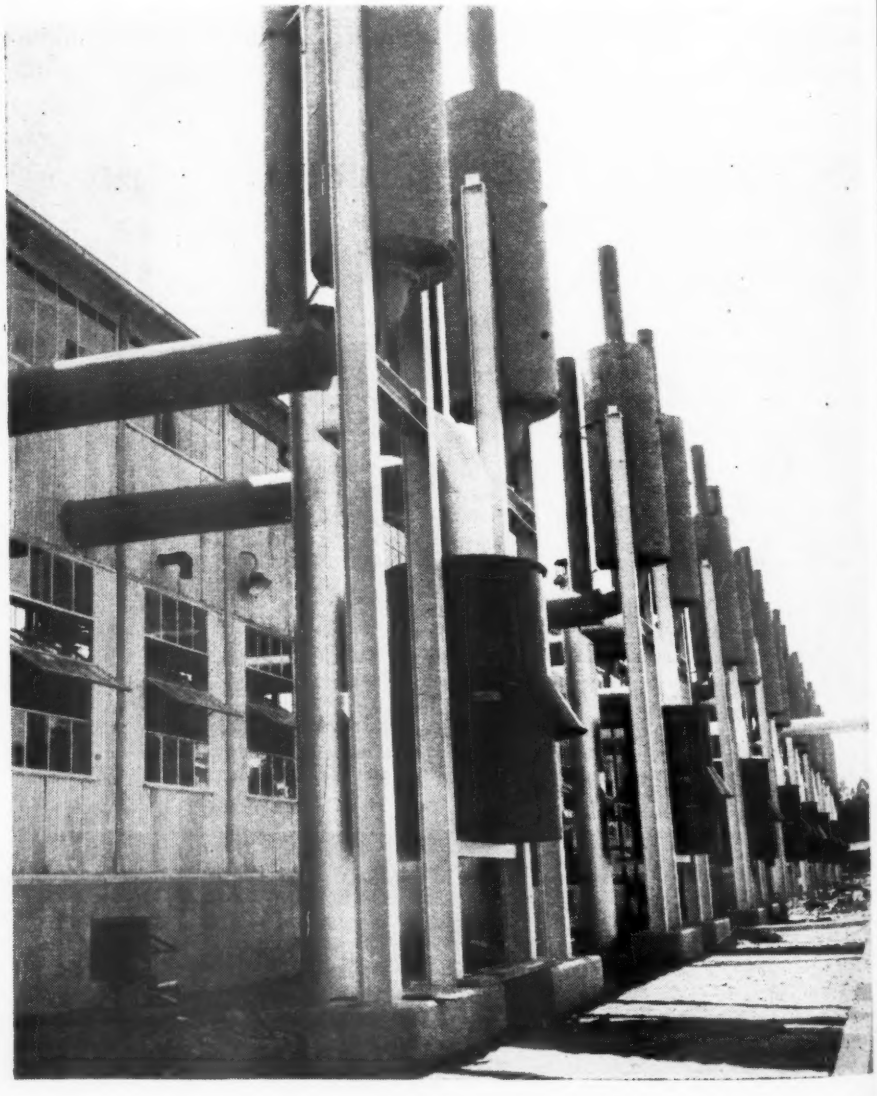
The generators of all units are of the standard open frame engine type, rated 312 kva., 250 kw. 480 volt, 3 phase, 60 cycles, with a 40°C. rise. The generators are equipped with 7½ kw., 125 volt, 1750 r.p.m., V-belt connected exciters.

Each engine has the exhaust muffled by a silencer. Intake air is cleaned by an air cleaner having a backfire relief valve.

The generators feed electric energy directly to a buss system contained in a unitized totally enclosed control center. From the center, electric power is distributed to all parts of the station.

Breakers are provided for engine ignition rectifiers, sump pumps, heater motors, circulating water pumps, air compressors, elevated water tower pumps, cooling tower fans and recirculating water pumps, well pumps, and plant lights. Spare circuits are provided, as well as a P. F. meter, indicating wattmeter, and totalizing and indicating kw-hr. meter.

The generator units are housed with the cooling system pumps and starting air compressors in a steel frame, galvanized iron covered building, 40 ft. wide by 78 ft. in length. A full bridge type craneway is provided for convenience in overhauling generators and pumps. The pumps are located in a 3 ft. deep



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That confidence is soundly based on their knowledge of the engineering facts and the welding methods, the uniformity of pipe thickness and consistent physical characteristics of SMITHway Welded Line Pipe.

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ed. Electric motor drive deep well pumps have been installed in these wells. These wells discharge through a check valve into the 2000-bbl. main water storage tank. Stations 10, 12, and 14 have supply sources from nearby streams and springs. Station 10 has a 10,000-bbl. main reservoir tank, and station 12 has two earthen reservoirs. These reservoirs, springs, and streams supply water to the 2000-bbl. water storage tank.

The feed water to the 2000-bbl. tank is controlled by a level controller with float ball in the tank, operating a 4-in. throttling type diaphragm valve on the feed line. The cooling tower basin water is supplied directly from this tank through a 4-in. line.

Stations 2, 4, and 6 each has an elevated tower tank approximately 40 ft. in height to supply pressure on the station and camp water systems. Water is supplied to this tank by means of two 80 gal. per min. electrically-driven centrifugal pumps, taking suction directly from the 2000-bbl. tank. These pumps are controlled by a hydrostatically operated electric relay that operates when the tower water level reaches a predetermined low point, and shuts off when a high level has been reached. Either one or both pumps may be used, as required. Stations 8, 10, 12, and 14 each has a standpipe 60 ft. high of 24-in. pipe serving as water storage tank. Water is supplied to these by small electric motor centrifugal pumps.

Fuel gas system. The fuel gas to each station enters a pilot-operated primary fuel gas regulator where the pressure is reduced from 400 to 200 lb. This regulator opens upon pilot failure. The 200-lb. gas from this regulator enters a secondary pilot-operated fuel gas regulator where the pressure is reduced to 100 lb. This regulator is duplicated by regulator in parallel; either will handle the full fuel requirements for the compressor station. Each of these regulators will close upon its pilot failure, the other regulator then taking the full load of the plant.

The primary regulator is spaced a considerable distance from the secondary fuel gas regulator in order to minimize the refrigerating effect of the gas expansion through each regulator.

The gas from the secondary fuel gas regulator enters a volume chamber where the flow of gas is smoothed out. The regulator control pressure line taps into this volume chamber, the reserve volume of gas preventing regulator "hunting." A 6-in. pipe line from this volume chamber acts as an orifice meter run. The fuel gas requirement for the station is metered through this run by means of a standard orifice meter. A recording thermometer is also installed in this run.

The gas leaving the metering run enters into a second volume chamber on the outlet of which is placed a balanced pressure regulating valve. The pressure is reduced from 100 lb. to the compressor fuel requirements by this regulator, and at the required pressure the gas is then supplied through a 10-in. fuel gas header to the compressor building, and through a 4-in. line to the generator building.

The generator fuel gas regulator is a sensitive type regulator that drops the pressure from 45 to 1 lb. into a small volume tank, which is protected from overpressure through a diaphragm control valve acting as a relief valve. The gas from the regulator volume chamber then enters the 6-in. generator fuel header. Each generator is equipped with a sensitive regulator, reducing pressure from 1 lb. to 3 in. of water. A volume tank is provided between the generator regulator and mixing valve.

The compressors do not have individual regulators, but a large main fuel header is installed and each compressor is provided with a large fuel volume chamber to smooth out surges and provide additional volume.

The primary regulator is installed in a valve box in the plant yard and the secondary and intermediate regulators, volume chambers, and 6-in. meter run, are housed in a separate steel frame corrugated galvanized iron building. The generator fuel regulators are housed in the auxiliary building. The secondary fuel, intermediate pressure, and generator fuel regulators are all duplicated as a precaution against shutdowns.

The gas fuel to the office building, pipe-line warehouse, machine shop, and

In the Tight Spots—

"CLEVELANDS" built-in adaptability to meet the many varied field conditions enable them to handle the toughest ditching jobs on the roughest going and in the tightest spots.

Some of the reasons why "Clevelands" come through under the most adverse conditions are:—

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3. Extreme ease of operation and maneuverability because of broad full crawler mounting.
4. The quickly reversible Arc Conveyor permitting the throwing of dirt on either side of the ditch at desired distance.
5. A multiplicity of digging and traction speeds always available to operator, enabling him to cut at maximum speeds for the work at hand.
6. Ample power to carry through in any soil and over the toughest terrain.

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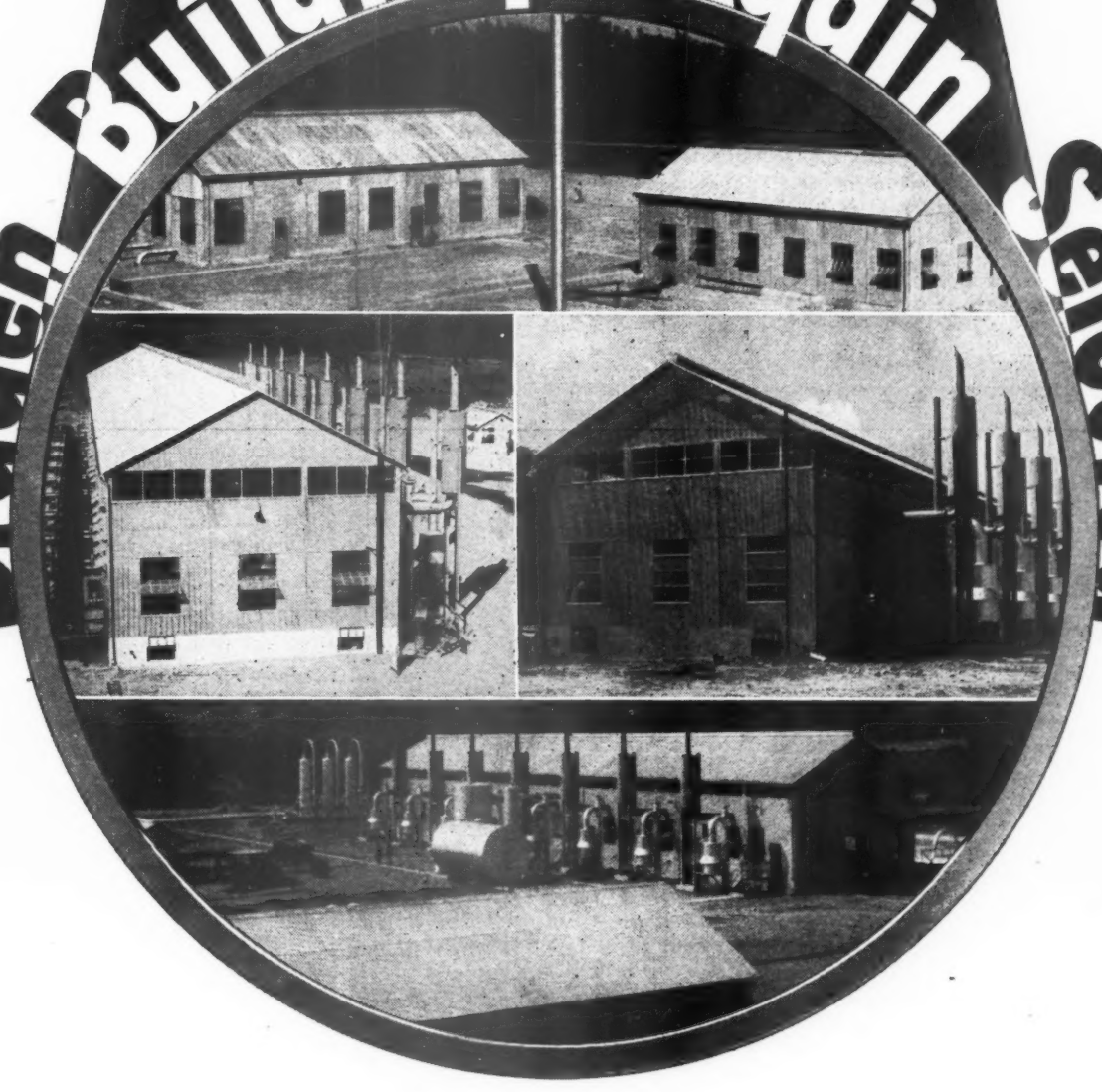

We consider it a compliment to Braden engineering and fabrication, to again have been selected to furnish a majority of the sectional steel buildings on one of the country's major pipe line projects.

Complete installations of Braden Sectional Steel Buildings were made by the Tennessee Gas & Transmission Company at their Batesville, Miss., Lobeville, Tenn., Campbellsville, Ky., and Burnaugh, Ky., stations.

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BRADEN STEEL BUILDINGS

change room building is measured through a displacement meter, and the pressure is reduced at each building by regulators handling the required fuel. These regulating valves have built-in relief valves and automatic shutoff features.

Speed control. As stations 12 and 14 are subject to fluctuating demand, automatic speed control has been installed in these stations. These automatic controls maintain the station pressure as required. The control center of these systems is a 2-pen pressure recorder-controller. One pen records station suction pressure; the second, or controller pen, is actuated from the discharge gas header pressure and controls air supply to a diaphragm motor with positioner for resetting the engine governor spring. A second diaphragm lever motor with positioner controls the scavenging air bypass and is in turn controlled by the gas manifold pressure. In action the automatic control acts to change the governed speed of the engine, and the amount of scavenged air is changed in proportion. Station 14 controller has an additional pen that records discharge pressure on low pressure system.

In stations 2, 4, 6, 8, 10, a 2-pen pressure recorder is installed in the compressor room and connected to record station gas discharge and suction pressure. These instruments may be changed later, if desired, to pressure controllers for automatic speed control service by inserting the pressure control elements in the instrument cases.

Building heating. Provision is made at all stations for heating the warehouse, shop and change room building and pipeline warehouse by means of individual gas-fired heater units. The offices at stations 8, 10, 12, and 14 are heated by gas-fired forced air furnaces. The offices at stations 2, 4, and 6 are heated by individual room type heaters. The compressor building and auxiliary building at stations 10, 12, and 14 are heated by means of 15 lb. steam. The steam is generated in a gas-fired boiler situated in the auxiliary building. Steam is piped to the compressor building through an underground conduit and thence to individual heating units.

The remainder of the buildings at these stations are not heated and on account of their geographical location, no provision is made for heat at stations 2, 4, and 6 for any buildings other than the ones that have been mentioned.

Provision is made in the auxiliary building at station 8 for the installation of a future boiler.

All boilers are served by condensate return units. These units have their own makeup control, return tank for controlling makeup water, and charging pump for boiler feed water. These units are mounted in the auxiliary building adjacent to the boiler.

The boilers are equipped with 20 in. by 25 ft. self-supporting steel stacks.

At each station a 20-gal. automatic hot water heater is installed in the office and a similar heater of 30-gal. capacity is installed in the change room. These units will provide hot water for lavatories and showers.

Maintenance facilities. The maintenance building, which contains the shop, warehouse, and change room building, is 30 ft. wide and 60 ft. long. The central section of this building, 30 ft. by 30 ft., is given over to warehouse space; bins are built along the walls and a small closed space is provided for housing electrical material. One end of this building, 12 ft. by 30 ft., is given over to a change room for employee use. This change room is fully partitioned off and is provided with adequate locker space, a wash fountain, a shower stall, and sanitary facilities.

The remaining space in the building, 18 ft. by 30 ft., is used for a maintenance shop. This section is provided with a monorail and hoist. In stations 2, 4, 8, 10, and 12 this shop is equipped with lathe, drill press, arbor press, grinder, welding equipment, and necessary tools to handle all but major repair work. The other station shops do not have machine equipment since large mechanical job shops are accessible. All station shops, however, can handle all minor repair work as they are equipped with the necessary hand tools.

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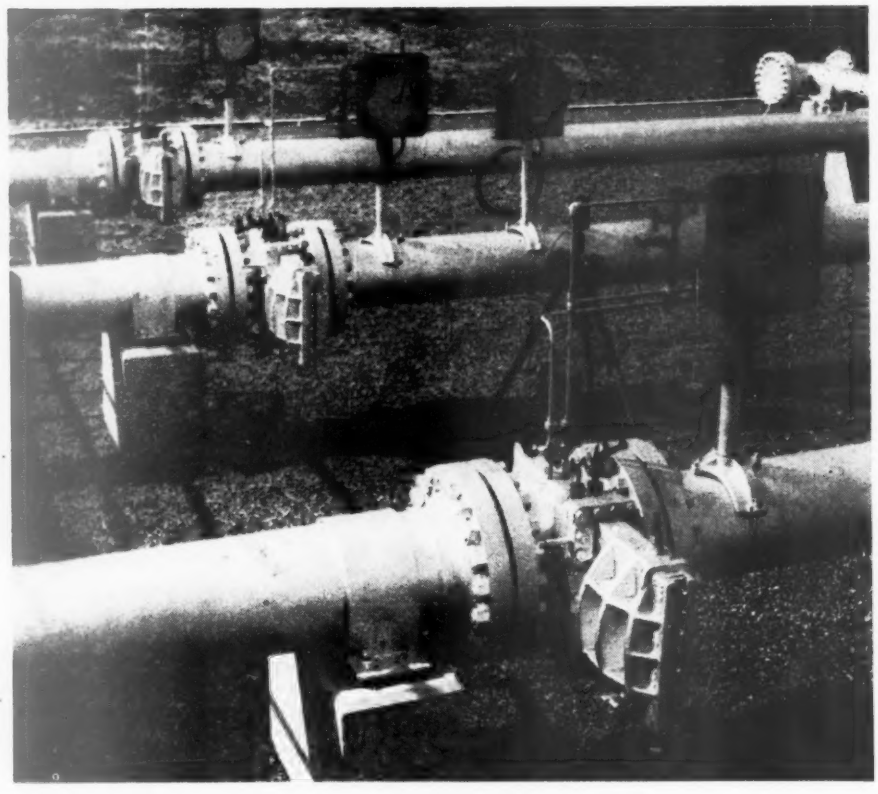

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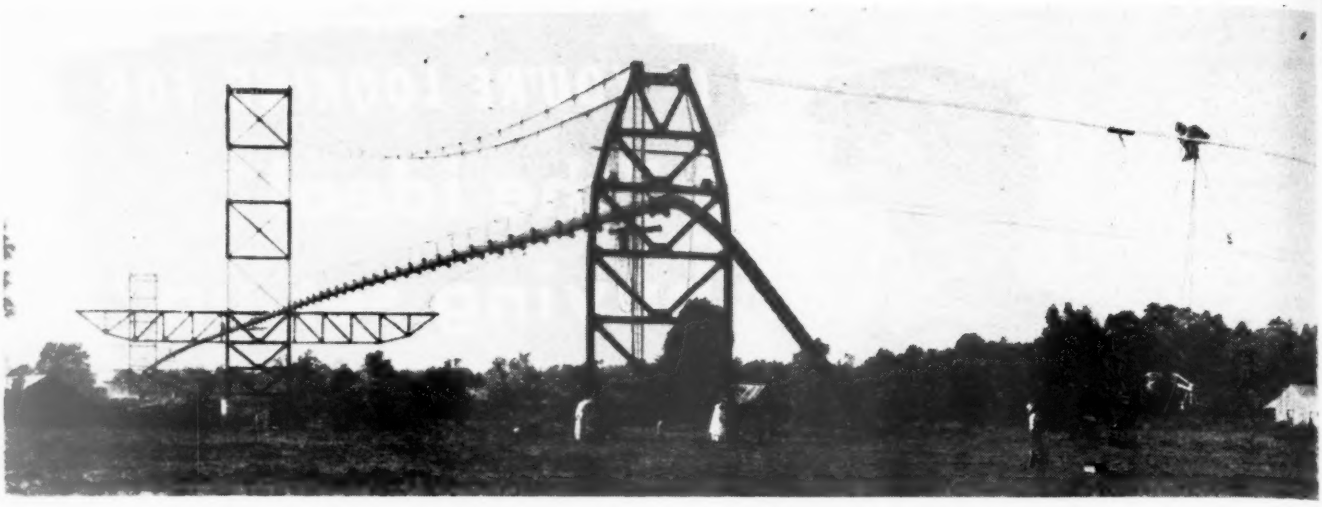


Red River crossing with main span 1280 ft. and one side span 640 ft. to total 1920 ft.

CONSTRUCTION OF AERIAL PIPE-LINE CROSSINGS

By **GORDON R. LUNT,*** Pittsburgh-Des Moines Steel Company

EXCLUSIVE THE Tennessee Gas and Transmission Company was granted a permit to construct a 24-in. natural gas pipe line from the vicinity of Corpus Christi, Texas, to Burnaugh, Kentucky, a distance of 1180 miles, and also 85 miles of 20-in. line terminating at Cornwell station, West Virginia, making the total length of the line 1265 miles.

Although officials of the Tennessee Gas and Transmission Company preferred to utilize overhead pipe line crossings for all major streams on their project, a decision was made, due to governmental restrictions involving the use of critical materials, to construct aerial pipe-line crossing only over those streams presenting the most severe problems and hazards.

The Pittsburgh-Des Moines Steel Company was selected and awarded a contract, on a cost-plus basis, to construct aerial pipe line crossings over the Red, Brazos, Sabine and Colorado rivers, and Matthews and Kenan, consulting engineers, San Antonio, Texas, were selected to prepare plans and specifications for these vastly important structures.

The location of each structure was held very close to the final layout of the line and as soon as the engineers had determined the lengths of span and the location of piers and anchors, test borings were made and from these findings the engineers were able to complete the design of the anchors and piers for each structure. Immediately after completion of foundation designs, material orders were placed, for time was a factor and materials had to be procured from many sources.

Upon completing the foundation designs, the superstructures were designed and materials were ordered from the mills. As construction work proceeded on the foundations, the engineers completed the final design drawings.

▶ **Red River aerial pipe line crossing.** The Red River aerial pipe line crossing, near Natchitoches, Louisiana, has a length, face-to-face of anchorages, of 2714 ft., a main span of 1280 ft. with one side span of 640 ft., making a total loaded length of suspended structure of 1920 ft.

Overhead crossings were provided for those rivers presenting the most severe problems and hazards— Details of work discussed.

The anchorage on the high side consists of two independent concrete anchorages, each 40 ft. long, 20 ft. wide, and 16 ft. deep. The single concrete anchorage on the low side is 42 ft. long, 20 ft. wide, and 16 ft. deep.

The main pier on the high side consists of two concrete bases 13 ft. square, 10 ft. deep with a connecting strut and two independent rectangular pier tops 4 ft. 6 in. high. Each base is founded on ten 10-in. H-pile driven to refusal.

The main pier on the low side consists of two steel caissons, each 13 ft. in diam. and 58 ft. long. These caissons were carried to grade, using the open dredging method and by loading with a 275-ton load box filled with sand dredged from the caissons. After the caissons were sunk to grade, twenty 10-in. H-pile were driven to refusal in each caisson, using a No. 1 Vulcan steam hammer. Then a seal course 8 ft. deep was poured in each caisson by use of a tremie. After the seal course had set sufficiently, the caissons were dewatered and filled with concrete up to within 12 ft. of their tops. The solid top course with connecting strut between the two caissons and remaining 12 ft. of caissons were poured monolithically; next were poured the 17 ft. pier tops.

The rest pier on the low side consists of two concrete bases 9 ft. square and 8 ft. deep with connecting strut and two independent pier tops 7 ft. high. Each base is founded on six 10-in. H-pile driven to refusal.

The main tower on the low side is 141 ft. 6 in. above the pier top elevations to the center of the main cables; while the main tower on the high side is 123 ft. 6 in. high. Both main tower columns are 28 ft. center-to-center; whereas the pin connected cantilever wind trusses have a total spread, from center-to-center of wind cables, of 165 ft.

The rest tower has a height of 51 ft. from the top of the piers to the center of the main cables and a spread of 22 ft. center-to-center of the columns at the base and 7 ft. 6 in. at the top.

*Gordon R. Lunt was graduated in engineering from the University of Iowa in 1921 and received his C.E. degree in 1927. He joined the Pittsburgh-Des Moines Steel Company, Des Moines, Iowa, in 1922 and is now manager of the bridge department as well as project manager of the wind tunnel department.

Each main cable consist of two 2⅝ in. diam. galvanized steel bridge cables, each 2765 ft. 4-11/16 in. long, face-to-face of sockets; each wind cable consists of one 2⅝ in. diam. galvanized steel bridge cable, 2735 ft. 7⅜ in. long. All suspenders and hand lines are galvanized Siemens-Martin strand.

All cable were erected by special methods and equipment developed by the contractor through years of experience in this highly specialized and unusual type of structure.

Upon completion of the cable erection, the 24-in. diam. pipe was erected by placing the two joints of pipe, which previously had been welded together on the ground, on welding platforms constructed adjacent to each main pier to the proper elevation. Bell-hole welds were made at each joint welded on the platforms; then the pipe was moved out on the structure by pushing two ways from the pier on the low side and one way from the pier on the high side.

The final welds were made at the center of the main span, adjacent to the pier on the low side and at each end of the structure.

After erection and welding were completed, the pipe was given a preliminary test with air at 125-lb. pressure, after which the pipe on the structure was connected into the main line previously completed and tested; then the pipe on the structure was further checked while being subjected to the same test that was used on the main line.

Brazos River aerial pipe line crossing. The Brazos River aerial pipe line crossing, near Wallis, Texas, has a length, face-to-face of anchorages, of 1754 ft. with a single main span of 920 ft.

The anchorages on either side of the river consist of two independent concrete anchorages, each 38 ft. long, 12 ft. wide, and 15 ft. deep, founded on H-pile.

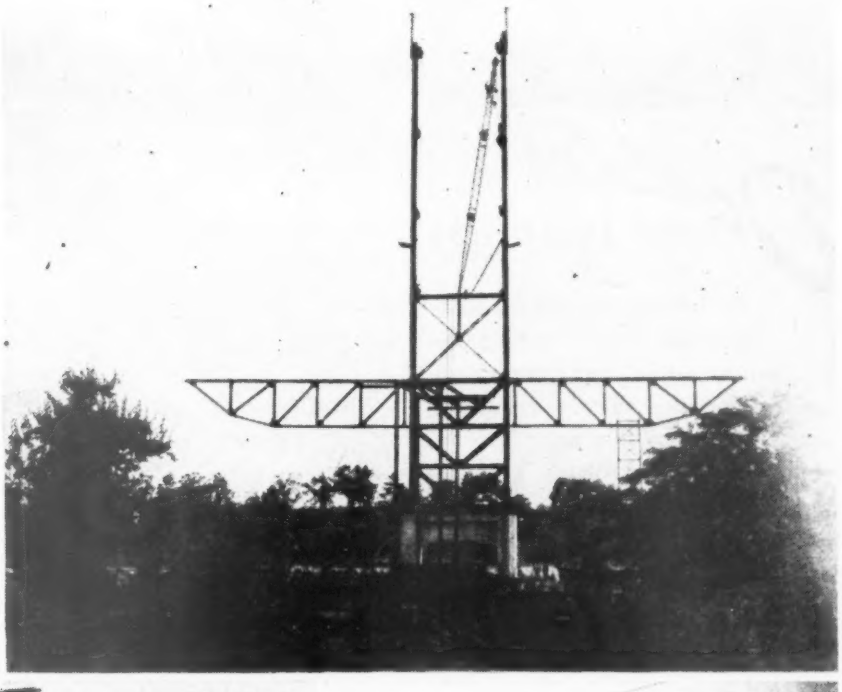
The duplicate main piers each consist of two concrete bases 12 ft. square, 10 ft. deep with a connecting strut and a pier top 14 ft. high. Each pier base is founded on nine 10 in. H-pile driven to refusal.

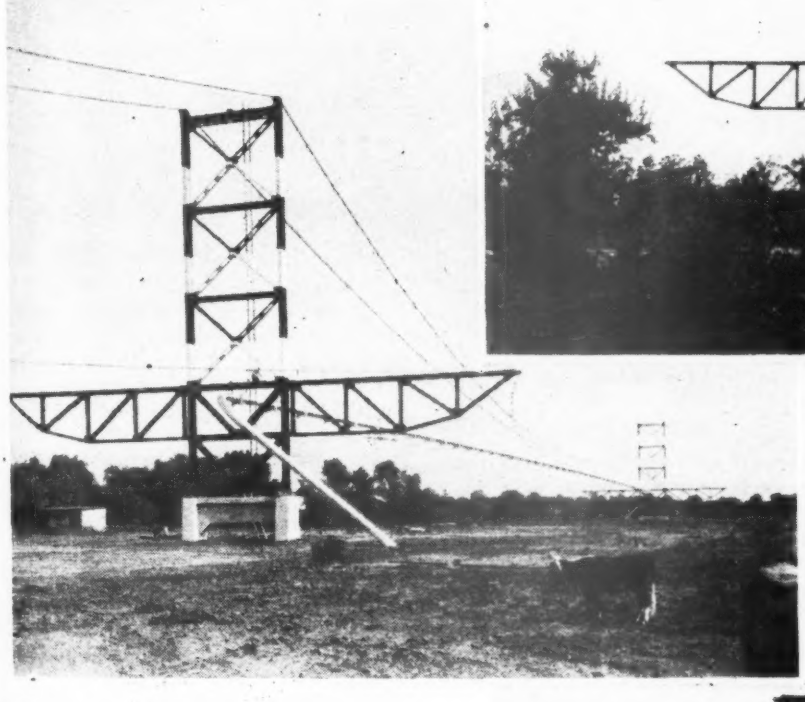
The main towers are 90 ft. above the pier top elevations to the center of the main cables. The tower columns are 24 ft., center-to-center, and the pin connected cantilever wind trusses have a total spread from center-to-center of wind cables of 135 ft.

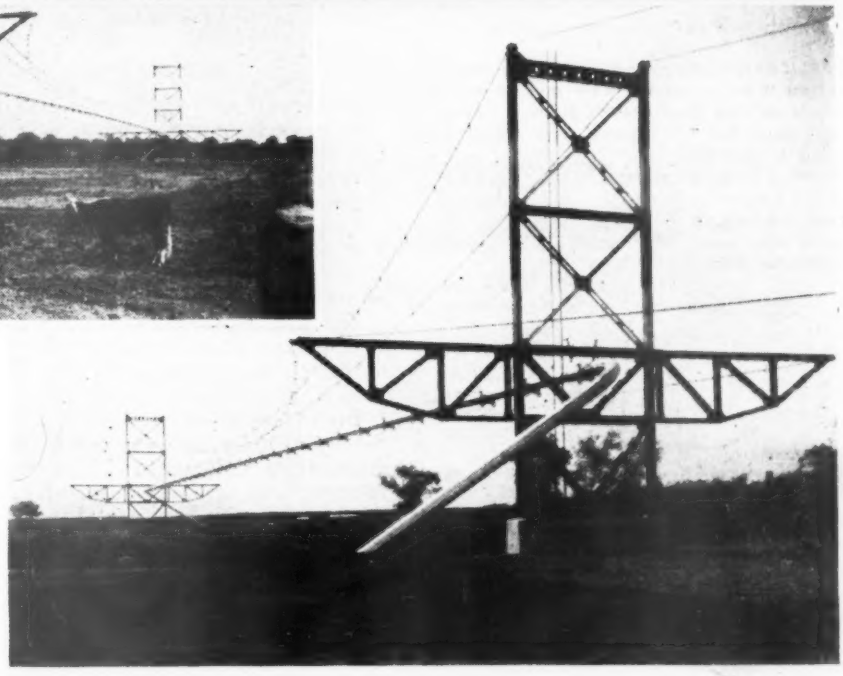
Each main cable consists of two 2⅜-in. diam. galvanized steel bridge cables, each 1783 ft. 3 13/16 in. long, face-to-face of sockets; while each wind cable consists of one 2⅛-in. diam. galvanized bridge cable, 1769 ft. ⅜ in. long.

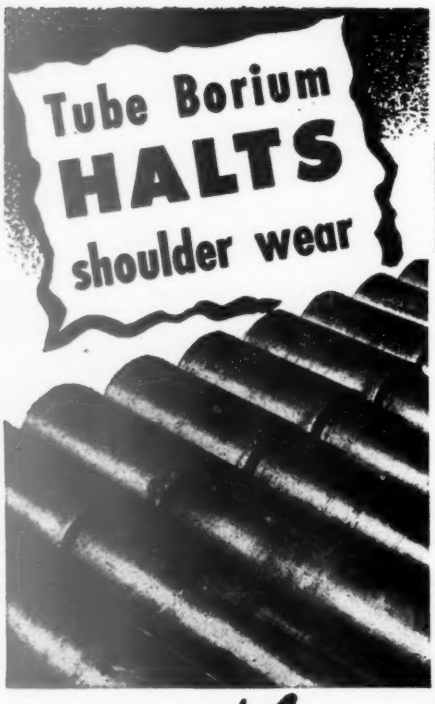
Colorado River and Sabine River crossings. The Colorado River aerial pipe line crossing is near Egypt, Texas, and the Sabine River crossing is about 14 miles from Hemphill, Texas. Each has a single main span of 600 ft. and they are duplicate structures insofar as size of cables, towers, anchors, and pier bases are concerned.

Top right shows the erection of the main tower of the low side of the Red River crossing. Bottom right is the Colorado River crossing, which has a clear span of 600 ft. Below is a view of Brazos River crossing with a clear span of 920 ft.









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For fifteen years Tube Borium has been used on drilling bits to increase cutting speeds and drill more out-to-gauge hole. Now you can use this same alloy to greatly prolong the life of your tool joints!

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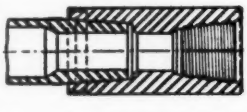
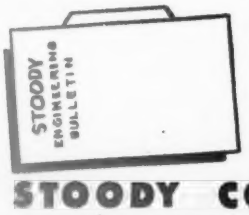
APPLICATION: Accepted method of application is to under-cut new or resleeved joints at the shoulder to form a recess ⅛" deep by 1½" wide. The recess is then filled by welding in with ¾" Electric Tube Borium to form the wear resistant inlay.





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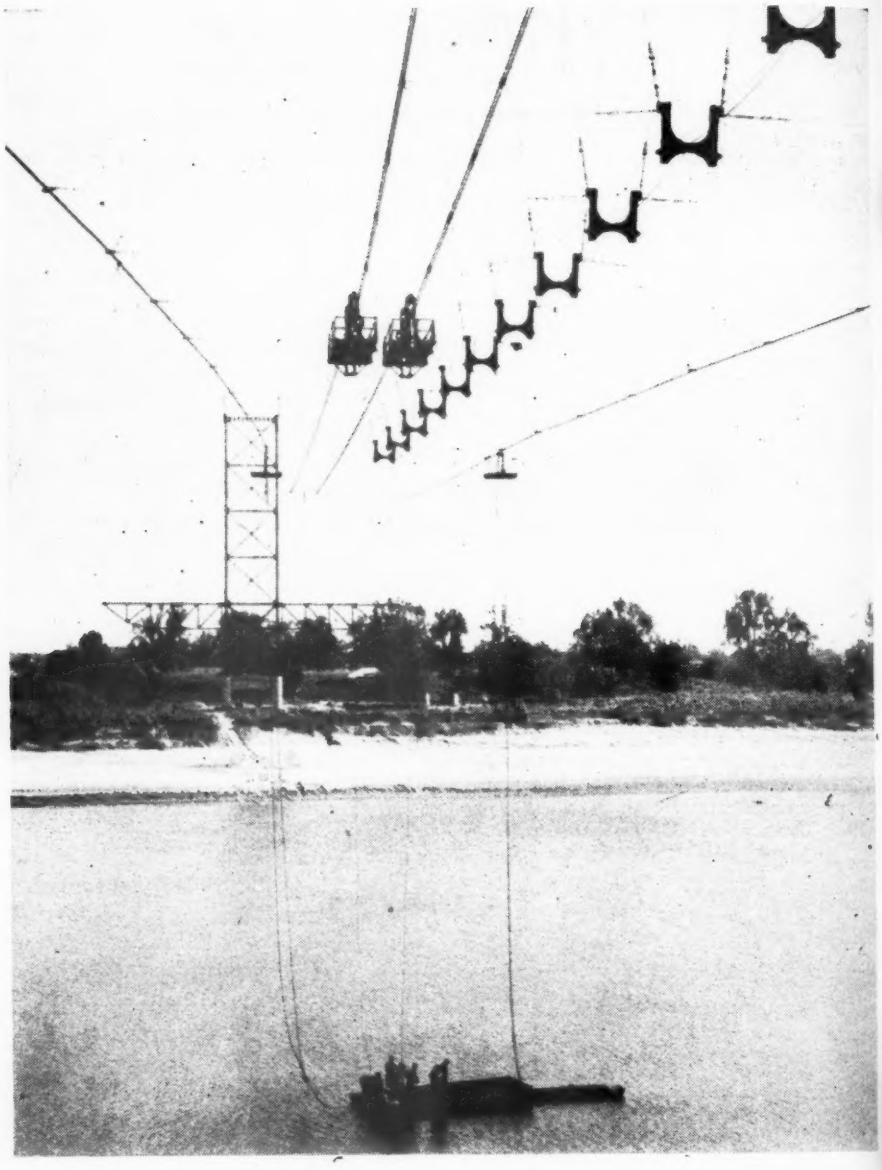

Scene at the construction of the suspender system on the Red River crossing showing construction crews in the boats below.

The anchorages on either side of the river of each structure consist of a single concrete anchorage 34 ft. long, 15 ft. wide, and 15 ft. deep, founded on H-pile.

Each main pier has two concrete bases 9 ft. square, 8 ft. deep, connected together with a strut. Each base is founded on six 10-in. H-pile driven to refusal.

The pier tops on the Sabine River structure are 12 ft. high above elevation of the top of pier base and on the Colorado River structure they are 8 ft. high.

Each main tower is 68 ft. high from the top of the pier to the center of the main cables. Columns are 22 ft., center-to-center and the pin connected cantilever wind trusses have a total spread of 90 ft.

Each of the main cables on each structure consists of a single 2⅝-in. diam. galvanized steel bridge cable and each wind cable consists of a single 1¾-in. diam. galvanized bridge cable.

All structural steel for the four structures was fabricated at the contractor's fabricating plant in Des. Moines, Iowa. All cables were supplied by John A. Roebling's Sons Company of Trenton, New Jersey.

The construction of the aerial pipe line crossings was under the direction of the writer of this article and A. C. Van Tassel was general superintendent of construction. The owners was represented by E. N. Armstrong and his assistants.

The construction of these four aerial pipe line crossings within the necessary and prescribed time limit was accompanied by many severely difficult problems. Excessive rains continued throughout a major portion of the construction period making the hauling of materials to the sites all but impossible. Floods greatly retarded construction progress; labor shortages and inefficiencies were an everlasting "headache." The surmounting of these problems necessitated a most unusual amount of perseverance and determination to the end that these structures were initiated into their long life expectancy of highly satisfactory service on schedule.

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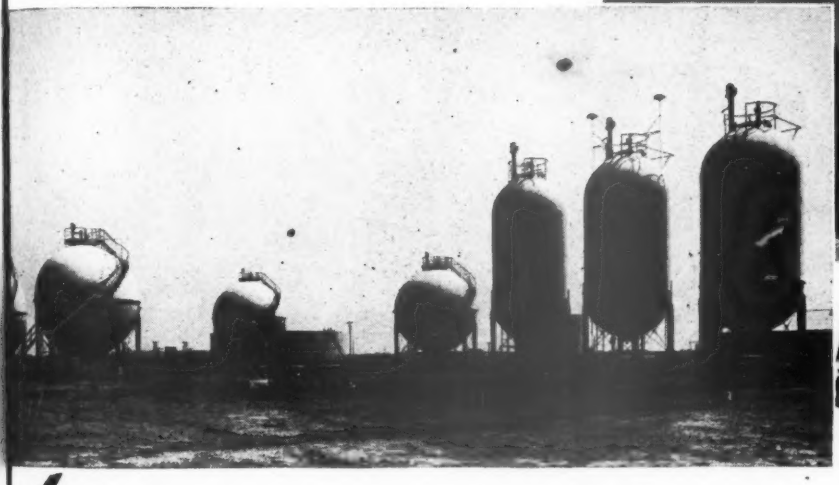

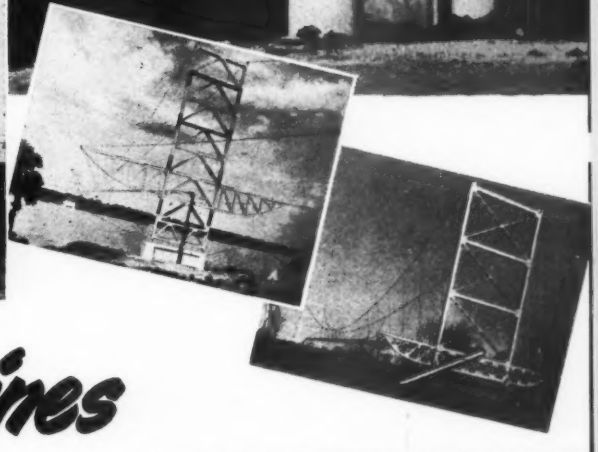

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PIPE PROTECTION ON THE BIG GAS LINE

By **STARR THAYER,** Consulting Engineer

EXCLUSIVE THE decision to build the Tennessee Gas and Transmission Company line came so suddenly, and speed of construction was so vital, that it was decided to use the experience of other companies rather than make extensive studies of potential corrosive areas in the right-of-way to be used. After all, the best information available regarding corrosiveness of soils is the past history of pipe lines in these or similar soils. In making coating recommendations for this line it was possible to use information and experience on old lines in a large part of the territory covered. In making such recommendations it was kept in mind that this was a much larger line than most of the older lines and therefore would be considerably deeper and in some places would encounter new soils.

From this information and from soil examinations it was decided to coat and wrap the entire line from the south end at Corpus Christi to the Dix River in central Kentucky. This is a distance of about 1045 miles. Of the remaining line about 40 miles was selected to be coated in three separate locations. It will be noted that no attempt was made to do any so-called "spot coating."

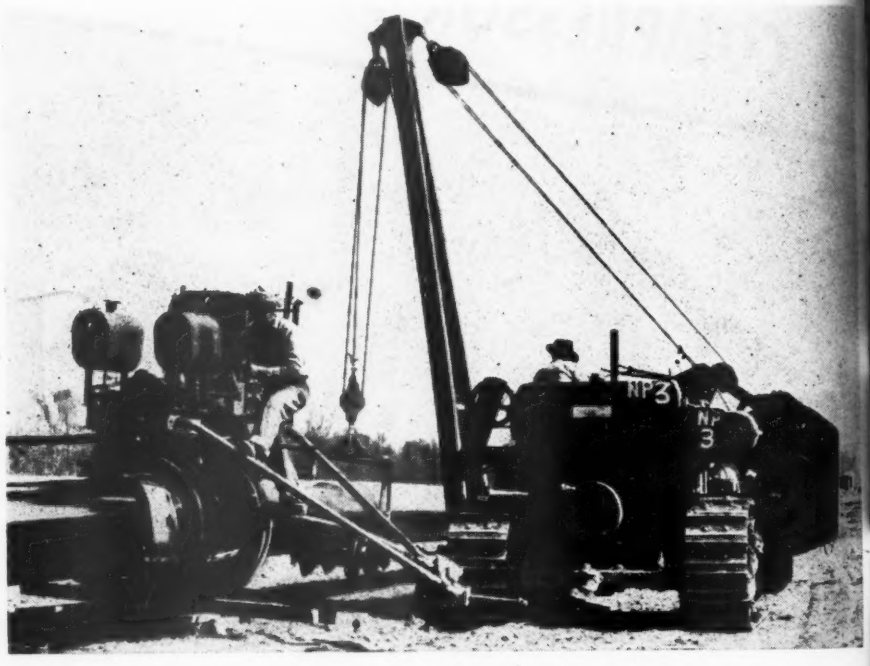
▸ **Selection of materials.** Coal tar enamels were used exclusively. That part of the line laid during cold weather was coated with waterworks type enamels, and regular 200° F. melting point pipe line enamels were used on the rest of the pipe. All coated pipe was wrapped with 15-lb. asbestos pipe line felt.

▸ **Coating procedure.** The main line was coated with one application of enamel and the wrapper. In all cases the primer used was of the same make as the enamel.

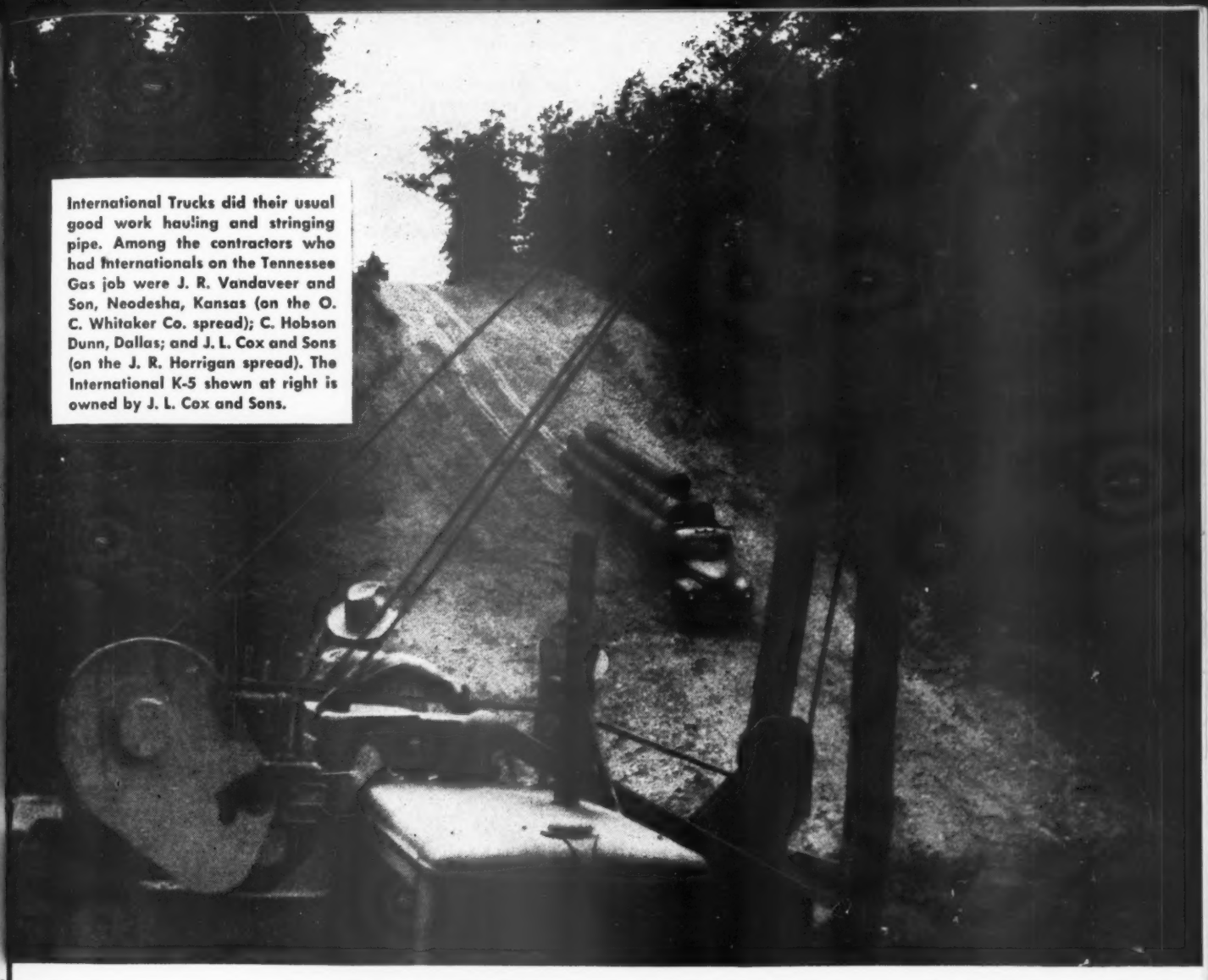
River crossing pipe was coated with two applications of enamel, the second coat immediately upon the first. Two thicknesses of the wrapper were then applied. No coating material was used over the wrapper. Wooden slats were used to protect further the coating during the pulling operation.

All station pipe was coated and wrapped in the same manner as the main line pipe.

(Continued on Page 192)



After the pipe was welded into sections it was cleaned and primed, as shown at the right. This operation was followed by coating and wrapping, performed by travel type machines like that shown below.



International Trucks did their usual good work hauling and stringing pipe. Among the contractors who had Internationals on the Tennessee Gas job were J. R. Vandaveer and Son, Neodesha, Kansas (on the O. C. Whitaker Co. spread); C. Hobson Dunn, Dallas; and J. L. Cox and Sons (on the J. R. Horrigan spread). The International K-5 shown at right is owned by J. L. Cox and Sons.

When it came to welding pipe, International Crawlers were in there pitching. This TD-18 with side boom is owned by Pressure Weld Co., Houston, and is welding on the N. A. Saigh Co. spread.

A veteran International T-40 pulling auxiliary equipment for pressure welding near Soda, Texas. This tractor, owned by J. R. Vandaveer and Son, was photographed on the O. C. Whitaker Co. spread.

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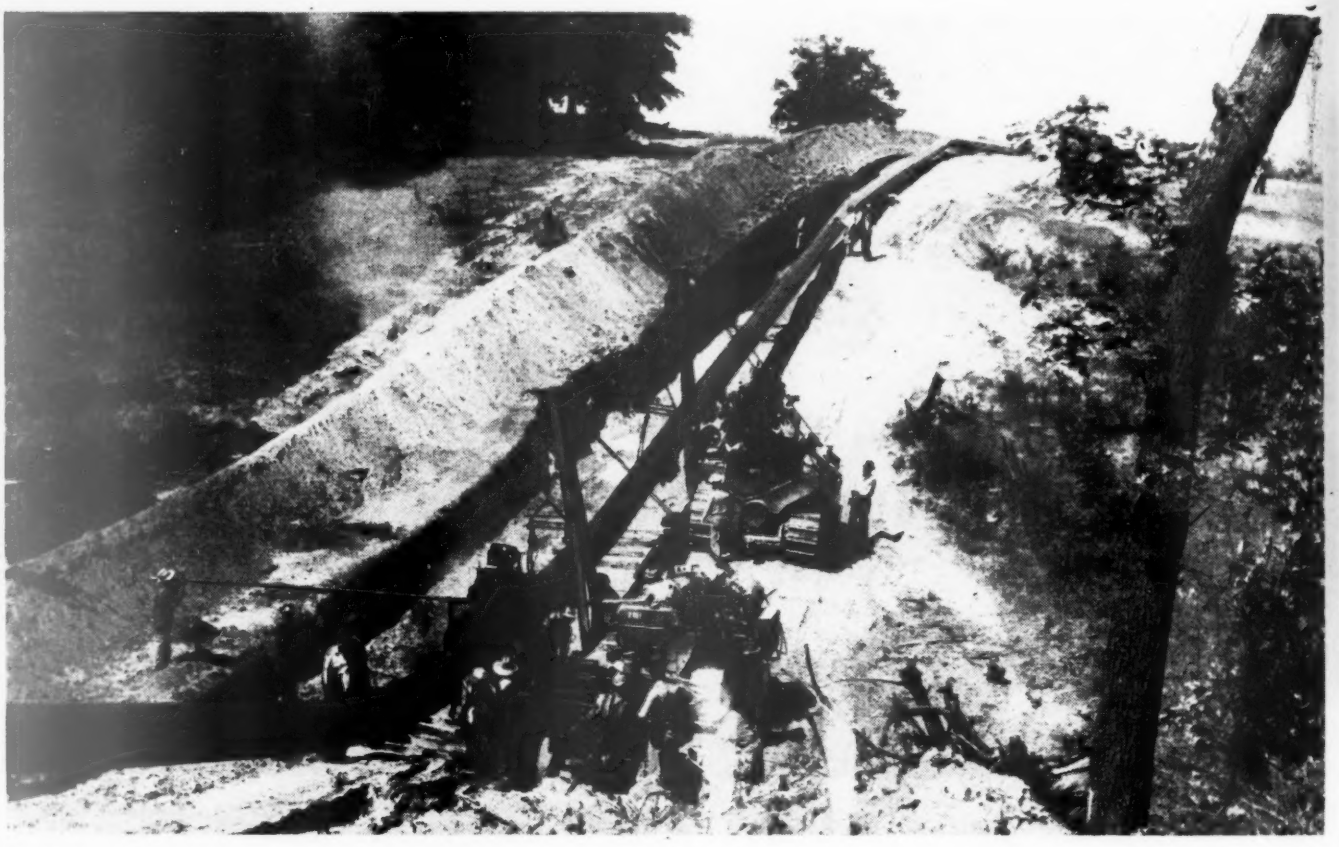
(Continued from Page 188)

All highway and railway casing pipe was coated but not wrapped. Insulated bushings were used to seal the ends of the casing pipe.

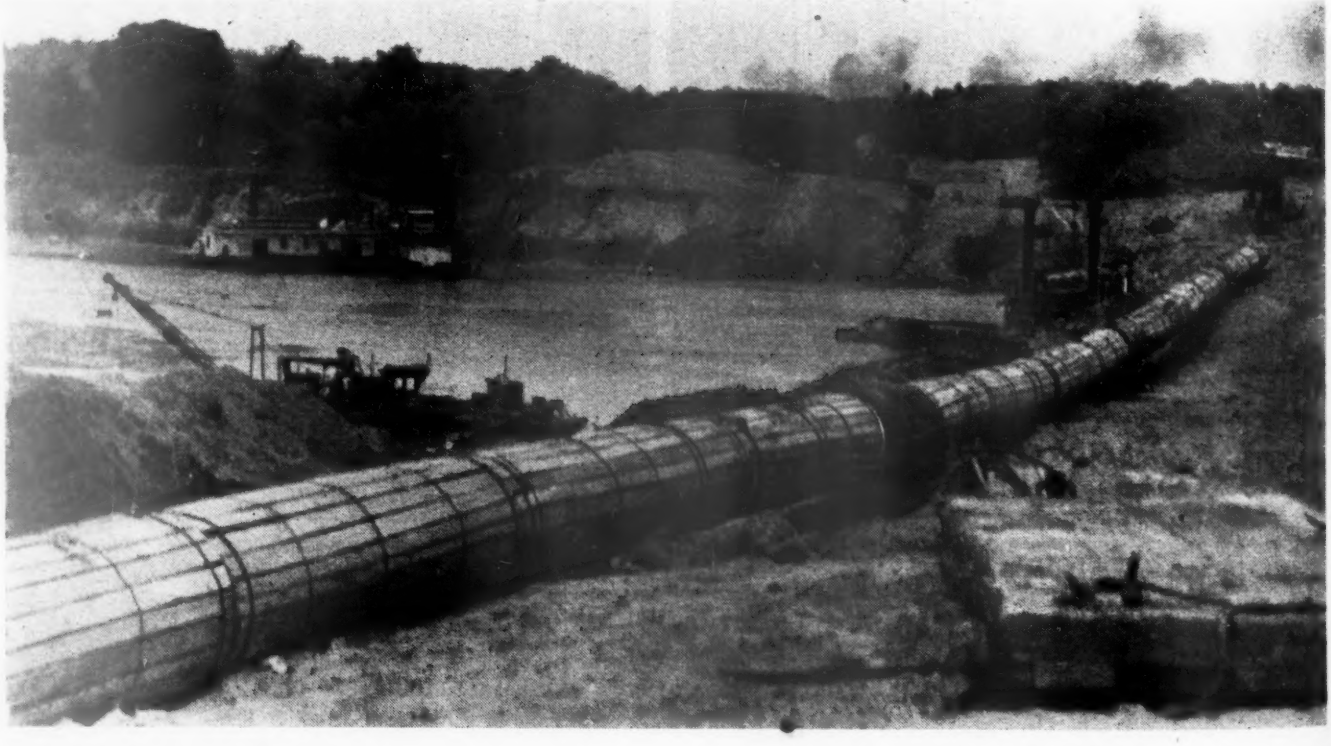
Method of application. The station pipe was either hand cleaned or sand blasted. Primer was applied by hand. Rolling rigs were used to apply the enamel and wrapper. The same method was used to coat the casing pipe except that it was hand cleaned and no wrapper was used.

River crossing pipe was machine cleaned and primed and the enamel and wrapper applied with rolling rigs.

After the main line pipe was strung and welded it was cleaned and primed with travel type machines. In some cases it was necessary to double clean before priming. On about two-thirds of the line a quick drying primer was used, which permitted the enamel to be applied within a matter of minutes after the primer had been applied. The amount of primer used was kept under close regulation. All skips, such as will occur at welds, etc., were hand brushed.



Coating and wrapping machine, showing bends (above). Wooden slats protected the coating and wrapper on river crossings.



Protecting Against Corrosion in Southern Swamplands

Down in the southern flat lands of Texas and Louisiana the new pipe line of the Tennessee Gas & Transmission Company encounters some of the worst soil corrosion conditions to be found in its 1300-mile bee-line from Corpus Christi, Texas, to, Kenova, West Virginia.

In this section of swamps, rice fields, low bottom lands of the Gulf area, the line is coated with Bitumastic 70-B Primer and Enamel to give it long-time, reliable protection against deterioration from corrosion.

Uniform coatings of Bitumastic 70-B Primer and Enamel, together with a 15-pound coal tar saturated asbestos felt, are applied to the outside surface of the 24-inch diameter pipe by line—traveling, cleaning and priming, coating and wrapping machines.

Bitumastic Enamel has been used to protect a very large percentage of this country's important gas pipe lines against soil corrosion. It has proved to be positive assurance against corrosion in all types of soil and under all variations of temperature. It gives *maximum* pipe line protection.

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All main line pipe was coated and wrapped with travel type machines. These machines apply the coating material and the wrapper in one operation. The coal tar enamel was pumped directly from the kettles to the machine. Kettle temperatures were closely controlled and it was necessary to dump but little material because of its being overheated. The crews were generally able to anticipate weather conditions sufficiently so that the material could be used immediately after reaching the proper application temperature.

It was impossible to get a perfect coating application over the wrinkle bends with the machine, consequently patch gangs applied coating to the skips at these bends and applied the wrapper by hand.

Lowering into the ditch was done in the early morning. Pipe of this size must be handled carefully to avoid damaging the coating, consequently all coated pipe was handled with wide slings made of belting.

▸ **Coating inspection.** Two experienced coating inspectors were attached to each construction crew. In addition, the lowering-in inspector, as well as the chief inspector, aided in seeing that a satisfactory job was done. One of the coating inspectors spent most of his time with the cleaning machine and the coating machine. The other inspector generally spent his time with the holiday detector crew and the patch gang. Virtually all main line pipe was checked for coating faults with the Stearns electronic holiday detector. As the pipe left the coating machine it was lowered onto skids. The coating was checked with the detector after the pipe was lowered onto the skids, and generally some distance behind the coating and wrapping machine. It was the principal duty of this inspector to see that the detector was in operating condition and that all faults found were repaired.

Right—Lowering the big pipe into the ditch by means of tractors and winch lines. Below—The Stearns electronic holiday detector was used to find flaws in pipe coating.

Pipe skids were not padded. Because of the weight of this large size pipe, padding would have caused a larger area of the coating to be damaged and require repairing, unpadded skids caused less damage. The pipe was marked by the detector crew at every skid and these areas were repaired just before the pipe was lowered into the ditch.

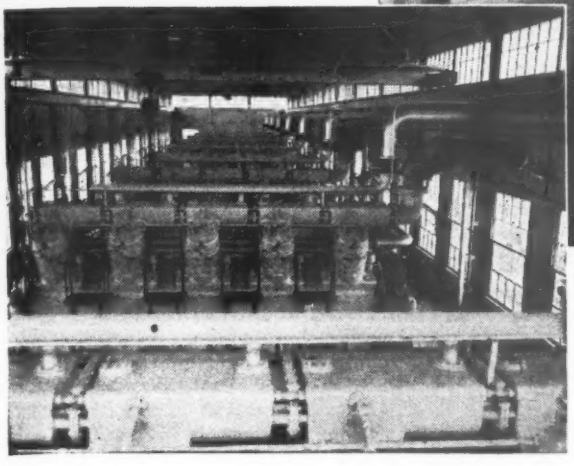
When the lowering-in crew started in the early morning their work was checked by an inspector. This inspector saw to it that all skid marks were repaired as well as all other places where the coating had been damaged after the regular patch crew had passed. This inspector had a holiday detector that was lighter and more portable than the Stearns machine. It was used only to check repairs to the coating.

▸ **Summary.** A very satisfactory coating application was procured. This was mainly through the efforts of the inspectors with the cooperation of the contractors. Both suppliers of coating materials provided service men, sometimes one man for each two construction crews. Most of these men were experienced in the coating of large-diameter pipe. They were of great assistance to the company in getting a good application and they were of assistance to the contractors in showing how to obtain a good application.

It is often said that the coating of a line slows up construction. There was no such occurrence on this line. At no time was forward progress delayed by the coating crews. In fact, coating crews generally were easily able to keep up with the pipe crews. There were days in which these crews coated as much as two miles of pipe.

▸ **Cathodic protection.** It is the intention to apply cathodic protection to the entire line eventually. For the time being

Unit of the Tennessee Gas and Transmission Company pipe line



Pipe line conceived and built by Tennessee Gas and Transmission Co.; Dehydration plant, seven compressor stations and two check meter stations, designed, engineered and constructed by Stearns Roger Mfg. Co. Prefabricated piping, pipe bends, and pipe clamps for Dehydration Plant, four compressor stations and both check meter stations and hand rails, scrubber oil tanks, etc., by Houston Pipe and Steel, Inc.

The Houston Pipe and Steel, Inc. is proud to have had a part in building the giant pipe line for the Tennessee Gas and Transmission Company.

Our experience, skill and processes used on this giant project can help to build better construction and greater cost economies into YOUR present or postwar projects. We have one of the best equipped plants in the nation specializing in pressure piping, process piping and metal fabrication—a large engineering staff of pipe and metal fabricating technicians and a production force of pipe fabricating and erecting specialists ready to get your project under way.

Why not consult us today? Our engineers will be glad to discuss your problems large or small without obligation.

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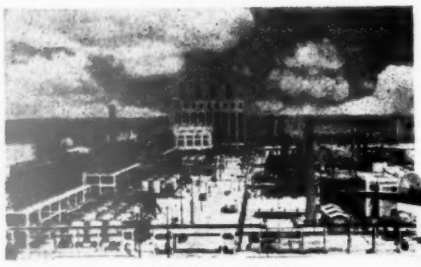

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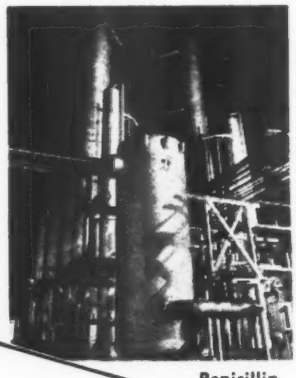

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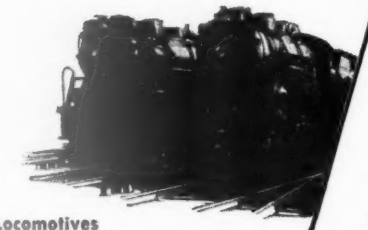

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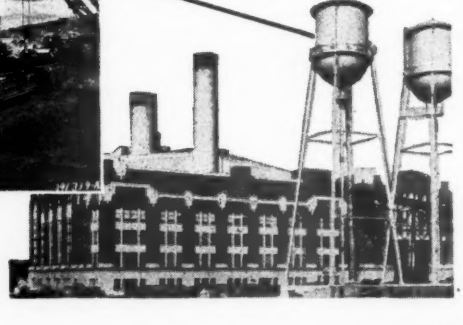

High Pressure Steam and Power

a 100-amp. rectifier is being installed at each of the compressor stations and at the dehydration plant near Corpus Christi. This is a total of eight units. When these units are placed in operation it is expected that they will protect all station piping as well as a considerable amount of main line pipe. Tests will be made to determine the location and sizes of any additional units that may be required to protect the entire line.

There are several miles of bare pipe in eastern Kentucky and in West Virginia. This area is very rough and the soil is mostly rock. It is anticipated that corrosion will not be serious in this area but it is contemplated that if any should be encountered then cathodic protection will also be applied to these areas.

A few tests have been made to determine current requirements to protect the main line. At one test less than 5 amp. protected about 22 miles of line. At another test 20 amp. protected considerable station piping and 30 miles of line. These small current requirements are a result of the excellent coating application referred to above and are proof that an excellent coating application has been obtained. This is best illustrated when compared to some other lines selected at random. One 6-in. line on which a good coating material had been used but poorly applied required 80 amp. for 40 miles of protection. Another 8-in. line laid under similar conditions and without experienced inspectors required 40 amp. for 25 miles of line. Still another, an 18-in. line, required 35 amp. for 5 miles of line. As we compare these figures with the 5 amp. required to protect 22 miles of this 24-in. line the results of strict inspection and good workmanship are readily seen.

It is probable that there will never be any serious trouble on this line due to corrosion. It has been designed as a corrosion-free line. ★ ★ ★

Pipe line proposed

A 26-in. pipe line to transport natural gas from the Permian Basin of West Texas and New Mexico to Los Angeles, California, has been proposed by the Metropolitan Natural Gas Company. The suggested line, costing $40,000,000, would have an ultimate capacity of 350,000,000 cu. ft. a day. Winkler County, West Texas, will be the location of a large field compressor station, and it has been proposed that a natural gasoline plant be built to operate in conjunction with the line.

Chester A. Ring, Jr., president of Metropolitan, has recently returned from a business trip to the West Coast where he investigated possible markets for gas from the Permian Basin.

Congratulations to the Management of the

TENNESSEE GAS AND TRANSMISSION COMPANY

--on the construction of their 24-inch gas line, under the most hazardous weather conditions and over extremely rough terrain.

We are very proud of the small part we have played in assisting them in this great achievement.

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• The 1263-mile, 24-inch natural gas pipe line of the Tennessee Gas and Transmission Company will be in operation next month. The line—one of the largest of its kind in the world—was coated and wrapped right in the field in a single operation . . . by the ingenious mobile Johns-Manville power-driven Coating and Wrapping Machine.

And, as in the case with many other large pipe lines, including "Big Inch", this pipe is wrapped with Johns-Manville Asbestos Pipe Line Felts. For hundreds of miles through water, mud, and corrosive soil, these lasting, rotproof felts safeguard its protective coatings against soil stress.

A better job—in less time . . .

For full details on how the J-M Coating and Wrapping Machine and J-M Asbestos Pipe Line Felts can guard your own lines against corrosion—and save you time and money in your pipe-wrapping operations—write Johns-Manville, 22 E. 40th Street, New York 16, N.Y.

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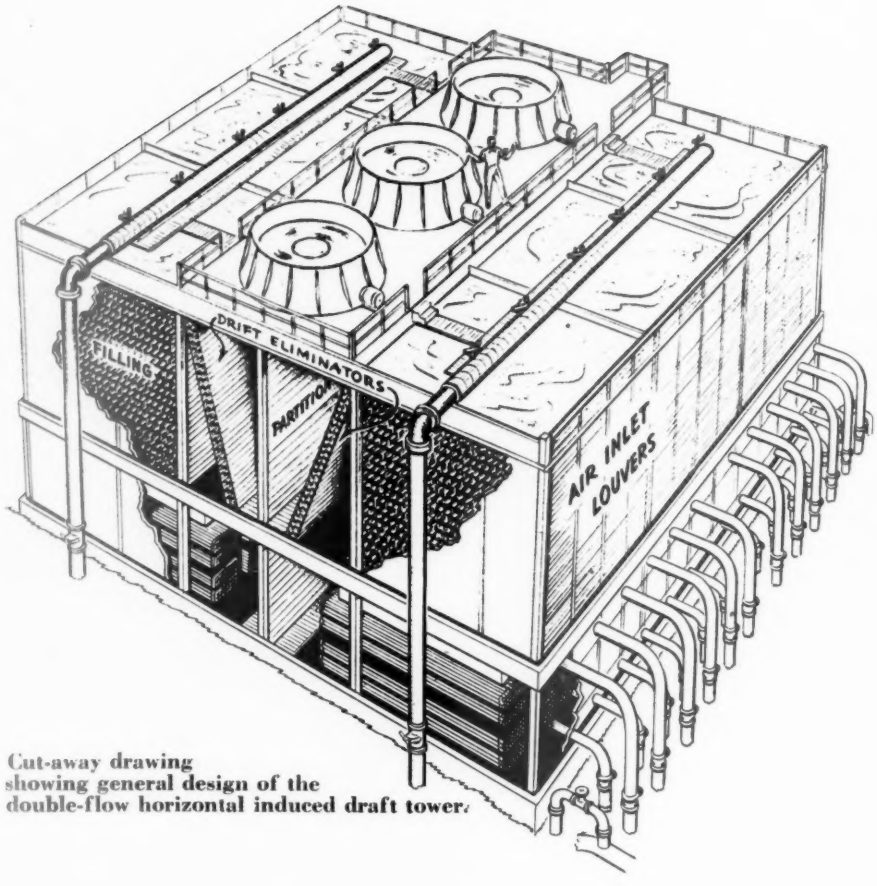


Cut-away drawing showing general design of the double-flow horizontal induced draft tower.

WATER COOLING EQUIPMENT

THE cooling tower, which is installed in exact duplicate at all 7 stations on the Tennessee Gas and Transmission Company line, is technically described as a Double-Flow horizontal induced-draft tower of the SpraCoil type. This terminology simply means that each fan draws air horizontally through two cooling chambers simultaneously. (See accompanying cut-away drawing.) SpraCoil is a designation for any tower having in its base a system of atmospheric heat exchangers over which the raw cooling tower water is showered to absorb heat through the tube walls and thus indirectly cool whatever fluid is circulated inside. In the case of these Tennessee Gas and Transmission Company towers, gas, jacket water, and the lube oil cooling water, in a number of separate circuits, are cooled to different temperatures, which are variable at will.

Stearns-Roger engineers were already thoroughly experienced with SpraCoil type towers of the "conventional" or vertical-air-flow design at numerous plants previously designed and built by the firm. Such towers had proved well adapted to some very complex services, especially in cycling plants, first by permitting all of the several indirect cooling functions to be combined in one cooling tower, and, second by providing independent and flexible operation for each function. This experience had demonstrated the value of having a "redistribution system" located at a level beneath the cooling tower proper and above the substructure (called a "coil shed') housing the heat exchangers. By this means the cooled water is collected in an intermediate catch basin from which it can be redistributed with complete uniformity over the heat exchangers below. Further, the volume of water showered over any of the separate systems of heat exchangers can be regulated just as cooling performance within the various fan-sections or "cells" of the tower is controlled by adjusting the supply of water and flow of air.

An unprecedented degree of operating flexibility was needed for the Tennessee Gas and Transmission Company installations, however. With all 7 towers specified for one predetermined gal. per min., the engineers asked that the redistribution system be so designed that the water volume to all stacks of coils not only could be decreased as in earlier towers but also increased far beyond design capacity. This ability to handle heavier loads was essential because of the likelihood that the line would see considerable future expansion, and it was hoped that foresighted engineering could spare the owners a great deal of revamping and enlarging of equipment. The ability to adjust to lighter loading would permit more economical operation at times when the line might not be at full flow.

IT was in the matter of operating flexibility, therefore, that the unique water distribution in the Double-Flow horizontal tower proved especially well suited to Tennessee Gas and Transmission Company needs. The primary system at the top of the tower supplies water to each cooling chamber independently and all parts are completely external, with control valves for each section readily accessible. Distribution in any "cell" is fully effective at any volume from twice the normal flow down to complete shut-off. Thus even the two cooling chambers served by the same fan may handle quite different loads.

Similar variability of the water quantities showered over the individual stacks of heat exchangers in the substructure is provided by a patented redistribution system. Sectionalized to correspond with each group of coil sections, this secondary water distributing system is actually a series of wholly independent reservoirs, each subject to easy regulation, whereby water volume over any or all stacks of coils can be increased to 100 per cent more than normal or reduced to a mere fraction of normal. Full, uniform coverage of the tube surfaces is maintained regardless of quantity and the shift from one extreme to the other, or any point between, is accomplished quickly and simply.

Both the primary and secondary systems operate by gravity flow.

The operating savings resulting from the tower's adjustability are proving to be a bonus worthy of notice. During cool weather and at times of light load the Double-Flow operates well by either of several alternative methods for conserving fan and pumping power:

1. In sufficiently cool weather the fans may be shut off completely and the water lifted only into the redistribution system, thus effecting a maximum reduction from normal power requirements.

2. If slightly more cooling is required the fans may be left idle but part of the water distributed over the tower through the primary system while the remainder is bypassed to the secondary system. Increased cooling is obtained as more water is put over the tower and less is bypassed. Ample air movement through the cooling chambers occurs by natural convection.

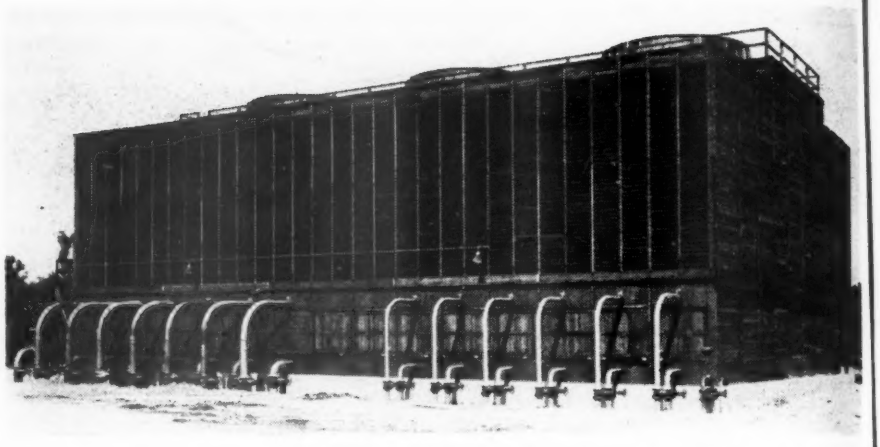
3. For still greater cooling the fans may be turned on, first only one, then two if necessary, and finally all three for maximum performance.

The tower, as built at all of the stations, is made up of 3 fan sections or 6 cells, 3 on either side. Each cell is five 6 ft. "bays" in length, for a total of 30 bays to the tower and a total tower length of slightly more than 90 ft. The tower's width, somewhat in excess of 60 ft., is sufficient to accommodate in the

ONE of our most recent jobs was the construction of a section of the Tennessee Gas & Transmission Company line. Every job we're doing today is helping to win the war. If you have a project that is essential to winning the war, we'll gladly offer the services of an organization that has the capacity, experience and resources to undertake any pipe line project.

PIPE LINE CONSTRUCTION CORPORATION

★ CAMP HILL, PENNSYLVANIA ★



Completed cooling tower, as installed at compressor stations on Tennessee Gas and Transmission Company line.

sub-structure two 30 ft. wide rows of coil stacks back-to-back. Any number of these separate coil stacks in either row can be operated at any capacity desired. Each of the tower's 30 bays accommodates one stack of coils. Nine of them are used for gas cooling, 12 for soft water that cools engine jackets and lubricating oil, and the remaining 9 are available for service as the line's loads increase. With gradually heavier transmission of gas through the line a virtual certainty, this reserve cooling capacity is sure to be needed shortly and can thus be put into use without requiring the services of the cooling tower manufacturer.

Total pumping head to the primary water distribution system at the top of the tower is only 30 ft., including the 10 ft. height of the substructure that houses the atmospheric heat exchanger stacks. For easy direct access to the coil sections, the entire walls on both sides of the substructure consist of solid doors on rollers. This convenient feature ties in with another device of exceptional merit, namely a patented air bypass damper whereby the hot saturated air off the coils is drawn upward in regulated volume into the suction chamber of the tower above and thence goes out the fan, along with the exhaust air that has passed through the cooling tower.

Perhaps it should be explained that in any tower having atmospheric coils in the base, evaporation occurs as the spray water absorbs heat from the tube surfaces, to such an extent that the wet bulb temperature of the atmosphere inside the coil-shed often exceeds 100°F. In the usual tower of the coil-shed type the sides of the substructure are either louvered to permit the escape of the hot vapor or they have hinged doors that are generally propped open much of the time for the same reason. The roller doors are more satisfactory from the operating and maintenance standpoint. But the vastly more important point is that these sliding doors are kept closed at all times while the tower is operating, forming a solid wall to prevent the emergence of hot moist air and thus forcing it to leave through the bypass damper.

The matter deserves emphasis because in towers lacking this mechanically-actuated ventilator the humid air issues forth from the coil-shed, rises of its own heat toward the tower's air intakes directly above, and inevitably large quantities of it enter the cooling tower. In effect—and in fact—it raises the wet bulb temperature of the air upon which the cooling tower depends for proper performance. The result is commonly a sharp curtailment of the cooling efficiency of towers.

In accordance with the specifications, all fans, drives, and other mechanical parts, are identical and interchangeable in all towers. Likewise all structural members and other wooden pieces are the same in every tower, even to the filling that occupies the interior of the cooling chambers. A feature of this filling worthy of mention is that it goes together by means of slots and mortises, using no nails or other rigid fastenings. Nor are bolts or nails used even to lock the standing 6-in. cubes of filling to the tower frame. Thus the redwood pieces can expand and contract freely and not get out of alignment. Also the successive levels of this filling are much closer together than in the usual fillings so that the amount of splash surface and total wetted surface is correspondingly greater. This does not result in excessive resistance to air flow, for in the Double-Flow tower air travels horizontally through the horizontal filling.

All parts requiring regular inspection or servicing are easily accessible by way of stairs, walks, or access doors. Fan motors are on the floor of the top-deck at the side of the fan rings, handy for servicing and outside the humid stream of discharge air. The fan rings are widely flared at the bottom to ease air flow, and are unusually high to act as guards as well as give the effect of a chimney to boost the expelled air away. All parts of the primary water distribution system are within open view and reach, while in operation, for easy examination or adjustment. Controls of the secondary or redistribution system, the air bypass dampers, and the heat exchangers themselves are reached from the ground outside or from walks on either side of the center partition running lengthwise of the tower. Access to drift eliminators and inner cubes of the filling is through the suction chambers. The air inlet louvers fit into channels at each end that permit them to expand and contract without warping or buckling, and also permit them to be instantly removed. Removal of the louvers exposes the outer cubes of the filling. Thus there is no part of the tower that could conceivably need to be examined or dismantled that cannot be reached readily and taken apart with the simplest tools or none at all.

The Tennessee Gas and Transmission Company station crews all use a universal manual of operating and maintenance instruction for the towers. As every part and detail of every tower is identical, a safe inventory of replacement items is quite small and there is no need to keep a specific stock at every location.

★ ★ ★

ENGINEERS & SURVEYORS

LOCATION & CONSTRUCTION SURVEYS

RIGHT OF WAY MAPS

OIL AND GAS PIPE LINES

SOUTHERN MAPPING & ENGINEERING CO.

HOUSTON, TEXAS

BANKERS MORTGAGE BUILDING

111½ N. GREENE ST. — GREENSBORO, N. C.

PALMETTO BUILDING — GREENVILLE, S. C.

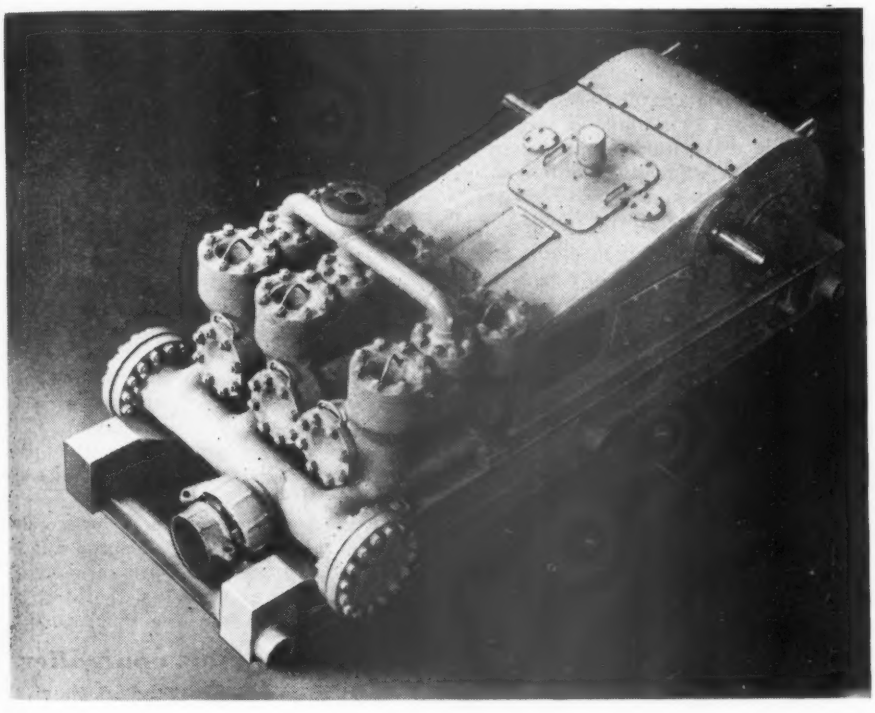
Ralph D. Stout C. O. Lowe F. N. Phillips, Jr.

Machinery and Equipment

Clark slush pump

Clark Bros., Inc., Olean, New York, announces the Clark Triplex Slush Pump. The power end of the pump embraces many features that combine to make for great power and durability, it is pointed out. For one thing, the main herringbone gear is bolted to the hub integral with the crankshaft. Also, power can be applied from either side of the pump through a double extended pinion shaft. The pinion shaft can be removed without disturbing the main gear assembly and operates on heavy duty roller bearings.

The main shaft is of unusual design, having eccentric hubs on the crank throws, uniting the advantages of both a crankshaft and an eccentric shaft. This design permits interchangeability of all main bearings and connecting rod bearings.



The pump cylinder is cast integral with a portion of the suction pipe, which is welded to similar suction pipes on the other two cylinders. All cylinders are of the "valve over valve" construction type. Discharge and suction valves can be removed through one valve cover opening.

Another feature of the pump is that the fluid end can be produced either in the piston type or the outside plunger type of design, making it applicable not only to the drilling industry but to other industrial fields as well.

The features of the pump are summarized by the manufacturer as follows:

1. Triplex double acting.
2. Even hydraulic power flow. Pressure variation in discharge reduced from approximately 45 per cent in duplex pump to approximately 14 per cent in triplex pump.
3. One-third less weight per hp.
4. Within 8 ft. road clearance.
5. Direct fluid flow. Valve over valve construction, both valves removed through one valve cover opening. Discharge valve can be lifted out by hand. With this construction and close clearance, slippage is reduced to a minimum.
6. Easy on prime mover. Reduced peak loads will result in lower maintenance costs on pump, engines, and transmission.
7. "Porus-Krome" plated cross head extension rod.
8. Fluid end tested 6000 lb. hydrostatic pressure. Recommended 3000 lb. working pressures.
9. All studs in fluid end same size.
10. Liners are supported near both ends to give extreme stability and are packed with two sets of packing with lantern gland between. This lantern gland lines up with tell-tale hole to show if either packing leaks, thus avoiding cutting out of fluid cylinders.
11. Double extended pinion shaft-power can be applied from either side.
12. No main bearing caps and bolts.
13. No connecting rod bolts.
14. Wide faced, herringbone gears of heat treated alloy steel.
15. Controlled splash and cascade lubrication.
16. Renewable crosshead guides in frame.
17. Long connecting rod ratio to stroke length.

Sterling Viking diesel

The Sterling Engine Company of Buffalo, New York, has announced a new line of diesel engines for the petroleum industry.

The result of 15 years' research and experimental work, the new diesel line ranges from 250 hp. to 650 hp.

Known as the Sterling Viking diesel, the engine embodies the latest features that have been produced as the combined efforts of Sterling engineers, headed by Hans Bohuslav, vice president in charge of engineering and designer of many sizes and types of diesels.

An important feature of its design, according to Addison F. Vars, president of the company, is that it provides a power plant with the same overall dimensions and same weight as most gasoline engines of equivalent horsepower and is interchangeable with Sterling's Viking gasoline engine.

Despite its compactness, it is easily accessible, permitting maintenance work and repairs to be performed with the least possible difficulty and loss of time, it is said.

According to ratings that the manufacturer sets, Sterling's line of diesels becomes in effect heavy duty power units for industrial and marine use.

Sterling's new line of diesel Vikings, forerunners of other lines of diesels being planned, is composed of four models, a 6-cylinder supercharged and unsupercharged, and an 8-cylinder supercharged and unsupercharged.

Horsepower ratings for the group are:

6-cylinder, unsupercharged, 250 hp. at 900 r.p.m. to 325 hp. at 1200 r.p.m.
6-cylinder, supercharged, 370 hp. at 900 r.p.m. to 500 hp. at 1200 r.p.m.
8-cylinder, unsupercharged, 330 hp. at 900 r.p.m. to 450 hp. at 1200 r.p.m.
8-cylinder, supercharged, 500 hp. at 900 r.p.m. to 650 hp. at 1200 r.p.m.

The weight of the 8-cylinder stationary type model is 8500 lb. The 8-cylinder marine engine, reverse gear, weighs 10,000 lb., and the 8-cylinder marine engine with reduction gear weighs 12,500 lb. The weight of supercharged models is approximately 500 lb. more in each instance.

Weights of the 6-cylinder models are 7000 lb. for the stationary, 8500 lb. for the marine, and 10,500 lb. for the model with reduction gear. Supercharged models weigh about 500 lb. additional.

The Viking diesel is a conventional type engine insofar as moving parts are concerned. It is a 4-cycle, multiple-cylinder, inline, trunk piston type engine, completely enclosed. The cast cylinder block is of single piece construction, containing the crankshaft main bearings at the lower surface with the wet cylinder sleeves inserted in the upper portion of the block. For easier handling, the cylinder heads are ar-

ranged individually for each cylinder and are fastened to the top of the block.

The cylinder heads are provided with 4 valves, per cylinder, 2 intake and 2 exhaust. They are actuated by push rods and rocker arms from the camshaft, which is located in the cylinder block and which is driven by gears from the free end of the counter balanced crankshaft.

The fuel injection system consists of individual injection pumps, one for each cylinder placed close to each injection nozzle.

Other accessories are mounted in a compact accessory drive box attached to the cylinder block and driven by the timing gears. All accessories may be readily removed without dismantling the engine.

The bore and stroke for all models is 8 by 9 in., giving a displacement of 2714 cu. in. for the 6-cylinder model, and 3619 cu. in. for the 8-cylinder type.

Marine engines can be provided with a built-in reduction gear of any required ratio up to 4 to 1.

On the marine engine the reverse gear is of the bevel gear planetary type with a multiple disk clutch operating in oil, and arranged for manual or remote operation of the reverse gear.

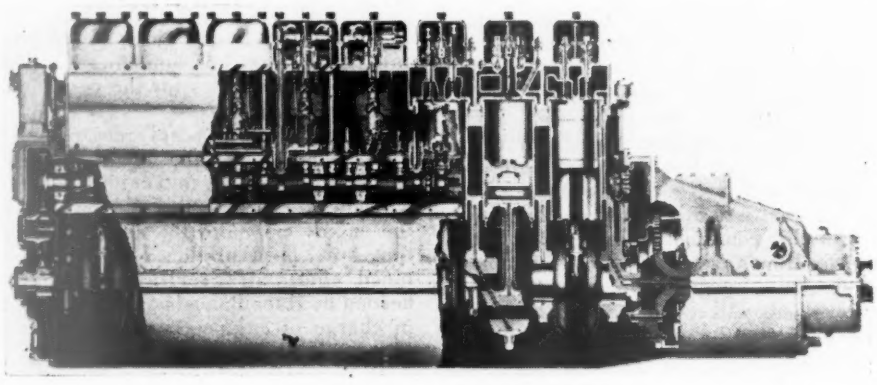
Starting is effected by two 32-volt electric cranking motors situated on each side of the engine.

The lubrication system, which is dry sump has two oil pumps, one to draw the oil from the sump beneath the engine and the other to supply forced feed lubrication to the bearings, including the wrist pin bearings.

Speed control is effected by means of a hydraulic governor having a wide range of speed regulations in the case of the Viking marine type engines, and having close speed regulations to meet all requirements in the case of the industrial and generator engine.

A battery charging generator and fuel oil supply pumps are provided, and other auxiliary pumps and accessories may be attached for special requirements.

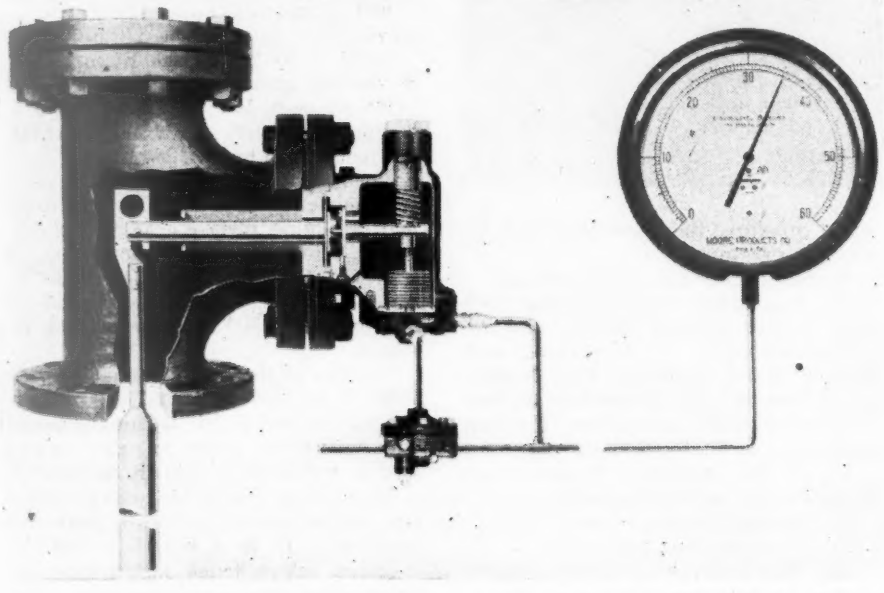
Sterling's Viking diesel engines are expected to find wide application not only for marine use, but wherever a dependable, economical and rugged power plant is required for rail cars, switching locomotives, oil-field drilling rigs and mud pumps, pipe-line pumping stations, electric generator sets, water pumps, fire pumps, sewage disposal plants, flood control projects, mine ventilating fans, power shovels, cranes, air conditioning equipment, and many other industrial applications.



Cross-section of Viking diesel engine.

Liquid level gauge

Moore Products Company, H and Lycoming Streets, Philadelphia 24, Pennsylvania announces a new liquid level gauge operating on the pneumatic "null" balance principle. The equipment consists of a transmitter with a Moore booster pilot valve, and a receiver that may be indicating, recording, or controlling, for installation at a distant point. The transmitter may be supplied with floats more than 60 ft. long, for installation on pressure tanks or on large tanks of spherical construction. Transmitters are also available mounted in float chambers, for the control of liquid level. It is especially well applied on hazardous or corrosive fluids, due to the packless construction and the ability to confine any leakage of hazardous fluids inside the safety pressure housing containing the balance mechanism. Construction is suitable for working pressures as high as 300 lb. per sq. in.



The transmitter operates on the principle of force change due to buoyancy of the liquid rather than a float following a changing level. A stainless steel disk carrying the float arm is mounted on the outlet of the tee. The tubular float is suspended from one end of the float arm and the balance bellows is connected to the other end. A small change of buoyant force on the float is balanced immediately by a charge of air pressure in the bellows. This is the pressure transmitted to the receiving meter. Due to the pneumatic "null" balance principle employed, all members are maintained in equilibrium. The change in the balance position on the bellows between zero and full scale is less than 0.001 in., thereby eliminating all nozzle and bellows nonlinear characteristics, as well as metal fatigue resulting from motion. This guarantees an accurate transmitted pressure, which is always linear with the change of level. Suitable stops are provided to keep any motion of the disk well within its elastic limit. Thrust pivots are provided for overload pressures. Stainless steel packless disk will distort but not rupture on pressures up to 5000 lb.

Potentiometer controller

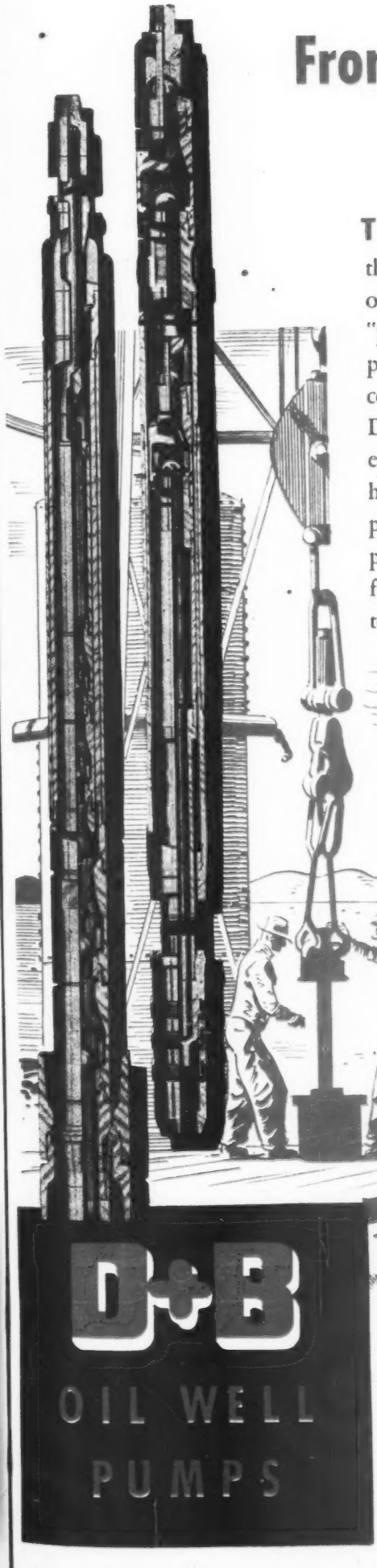
The Bristol Company, Waterbury 91, Connecticut, announces that time-program control is now available on their new Model 431 pyromaster potentiometer pyrometer, recently developed.

These time-program controllers automatically regulate temperature, not necessarily at a fixed point, but rather carry it through a predetermined series of changing values. Blank metal cams with time and temperature graduations printed on the cam face enable the user to cut his own cams with a pair of tin snips.

The controller can be any of the 5 air-operated types of several electric types of control manufactured by The Bristol Company, and in ranges up to 3000°F. for thermocouple type controllers and up to 3600°F. when used in connection with the company's compensated radiation unit.

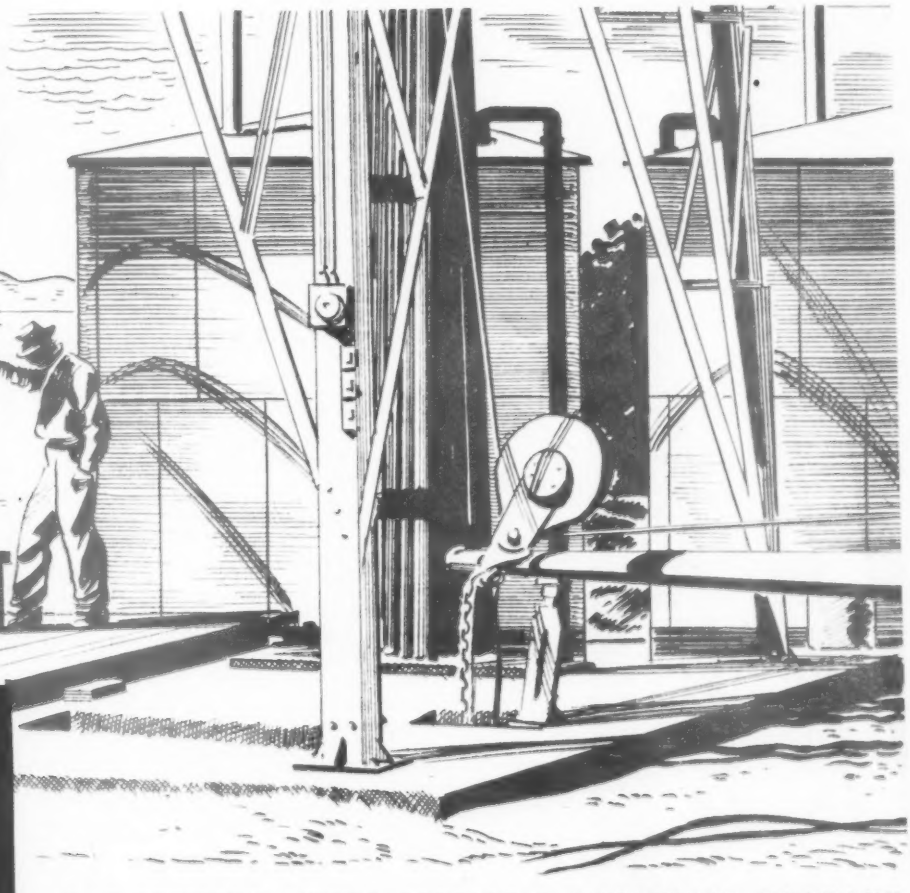
Bulletin P-1200 describes the new instrument and gives complete details on the Model 431 pyromaster potentiometer pyrometer.

From Well Bottom to Batch Tank With *Fewer "Pulls"*



There are wells in operation today that have been pumping continuously for months on end with never a "pull-out" for replacement of pump parts or other repairs. A large percentage of these wells are serviced by D+B Pumps. From the start of our experience some 40 years ago we have pointed toward manufacturing pumps which would wear well, pumps which would wear long and function sight unseen for long intervals without repair. Our attention to scientific design and constant improvement in materials and workmanship have paid dividends. D+B Oil Well Pumps give exceptionally long wearing quality under any bottom hole conditions.

D+B Pumps are designed and built in varying sizes, lengths and styles. For shallow wells, deep wells, normal production, or deep lifting problems, you'll find a D+B Pump that's just right for efficient, economical production.



D+B OIL WELL PUMPS

D+B DIVISION EMSCO DERRICK & EQUIPMENT COMPANY

LOS ANGELES, CALIF. • DALLAS, TEXAS

Distributors

California: D+B DIVISION, EMSCO DERRICK & EQUIPMENT COMPANY
Mid-Continent: THE CONTINENTAL SUPPLY CO., Dallas, Texas
Export: THE CONTINENTAL SUPPLY CO., INC., New York, N. Y.
Canada: THE TURNER VALLEY SUPPLY CO., Calgary, Alberta, Canada

Fire extinguishing agent

The DuGas Engineering Corporation, Marinette, Wisconsin, announces the development of an improved dry chemical for use in its dry chemical fire extinguishers. This new dry chemical, known as "Plus-Fifty DuGas Dry Chemical," is now available from all DuGas distributors and does not require a priority because critical materials are not used in its manufacture.

Hundreds of practical fire tests have shown the new dry chemical to be a much more effective extinguishing agent than the dry chemical previously used—a product well known for its excellent fire extinguishing properties, the manufacturer states.

These improvements in fire extinguishing effectiveness have been obtained without sacrificing the well-known favorable characteristics of DuGas extinguishers, it is asserted. The long effective range of the stream has been retained and the new dry chemical hangs in a cloud over the fire area, providing a greater smothering action and reducing flashbacks. The long effective range of the stream has always been an advantage to the inexperienced operator who was enabled to knock the fire down from a safe distance. With the new dry chemical the inexperienced fire fighter is able to use these extinguishers even more effectively.

The improved dry chemical has the same water repellency, non-caking, non-corrosive, and non-toxic properties that have been standard with DuGas dry chemical. It has the same non-conductivity to electricity and thus retains its suitability for use on fires in live electrical equipment. And like the former DuGas dry chemical, the new product is harmless to electrical equipment.

The new DuGas dry chemical is approved by the Underwriters' Laboratories and the Factory Mutual Laboratories.

Tipping tools

Carbide and high speed steel tipped tools are generally tipped by preplacing a strip of brazing alloy, together with a sufficient amount of flux, between the tip and the shank. The assembly is then placed in a furnace, or heated with an induction coil. This procedure, however, is sometimes objectionable, as the foil may become tarnished or oxidized and then require a temperature considerably above its own melting point to flow freely. Experiments have proved that the use of alloys in powder form would present definite advantages over the use of silver brazing alloys in the form of foil, according to Eutectic Welding Alloys Company, 40 Worth Street, New York 13, New York.

There are, therefore, two outstanding silver-copper and one copper alloy used for tipping tungsten carbide and high speed steel tools now available in a fine powder. These alloys are very economical in use since the required flux is

mixed right in with the powdered alloy. This eliminates any waste of flux during preparation. Then, too, the powder does not require the special handling necessary for cutting the foil into small pieces for exact preplacing.

These alloys are known as:

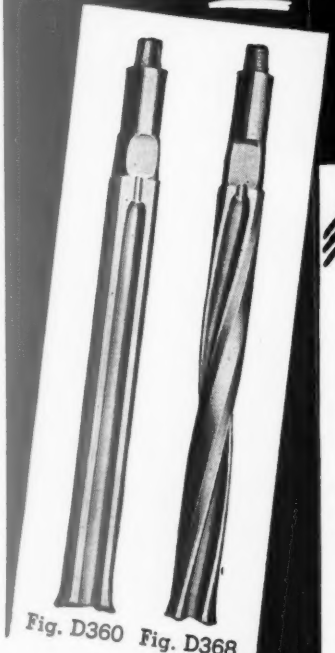
EutecRod 1800 (lowest melting) for H. S. S. 940°-1140°F.

EutecRod 1601 (high tensile) for Tungsten Carbide 1020°-1250°F.

EutecRod 16 (heat resistent, high tensile), for Tungsten Carbide 1300°-1750° F. (furnace temp.).

After the customary degreasing and grinding, the powdered alloy is spread on the surfaces to be joined, and the tungsten carbide tip is placed on top. The assembly is then heated until the alloy melts. The metal flows freely at a very slight increase in temperature above the melting point since the weld metal is pulverized. Oxidation of the tungsten carbide is prevented, as each particle of molten alloy immediately "tins" and adheres to the surfaces being joined.

FOR THE BEST IN CABLE TOOLS



SPANG HEAT-TREATED DRILLING BITS

Spang Drilling Bits are forged by a patented process which assures a sound, homogeneous product. The steel is made to specifications, which have been developed out of a long experience, to give the maximum of footage per dressing.

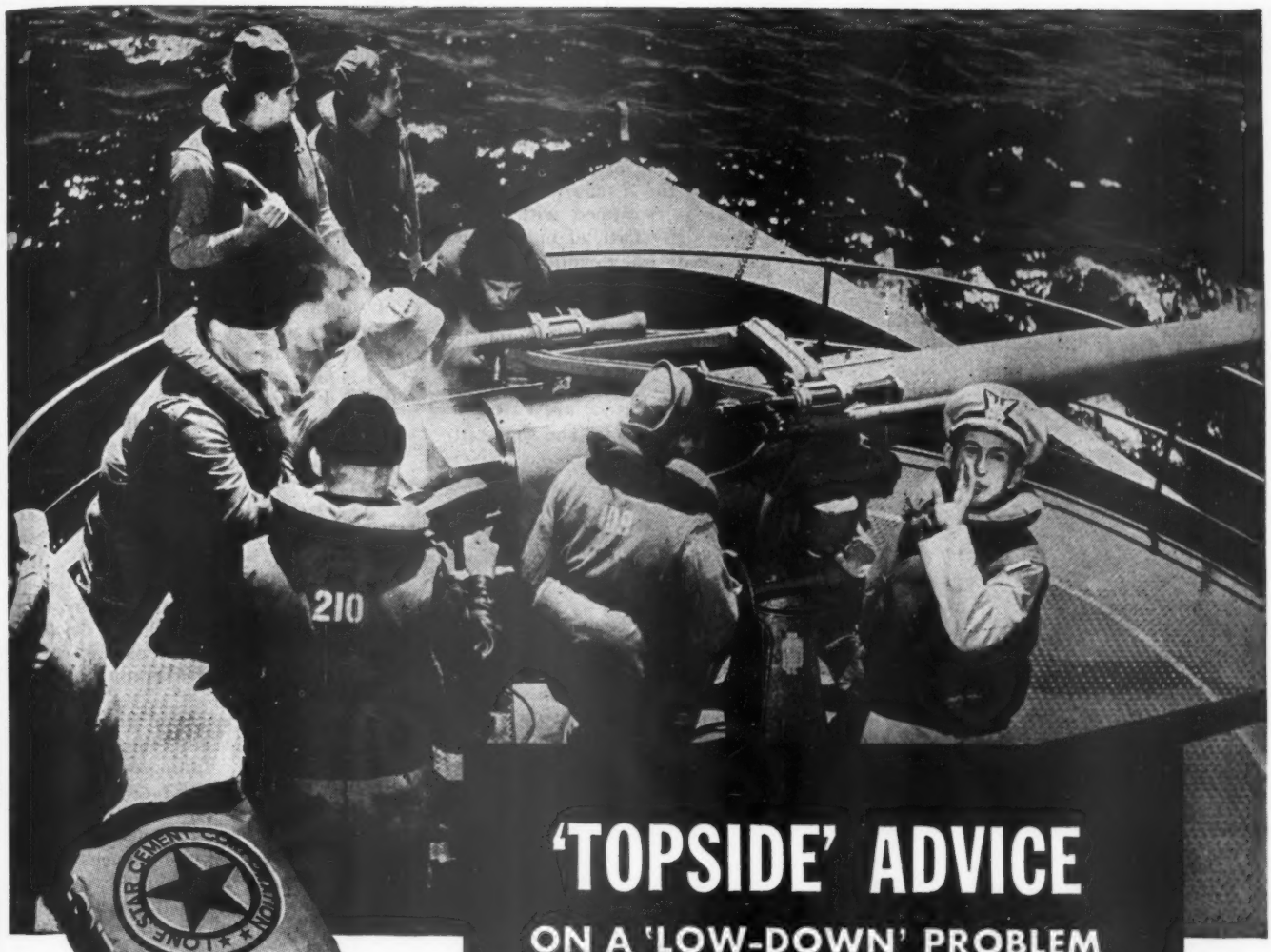
In the heating and forging operations, the most modern methods are used. Each step is carefully planned and executed to produce sound forgings. Heat treatment by use of modern furnaces with heat-recording instruments and experienced personnel insures the maximum of joint strength. A field dressing instruction chart is yours for the asking.

Spang Drilling Bits reflect the skill and knowledge that make every Spang Cable Tool a "Higher Standard" product.

THE HIGHER STANDARD

SPANG & CO.
BUTLER, PA.

YOUR DEALER SELLS SPANG TOOLS



'TOPSIDE' ADVICE

ON A 'LOW-DOWN' PROBLEM

"Sub off the starboard bow!" The Deck Officer gets directions from the Bridge . . . some quick, straight shootin' . . . and the sub's bow jumps high out of the water. Another tanker convoy saved . . . so vitally needed oil may reach world-wide battlefronts. Protecting production in the well is equally important. And that's where good cement, specially made for Oil Field service, is doing its share . . . in new wells and for repairs and reconditioning.

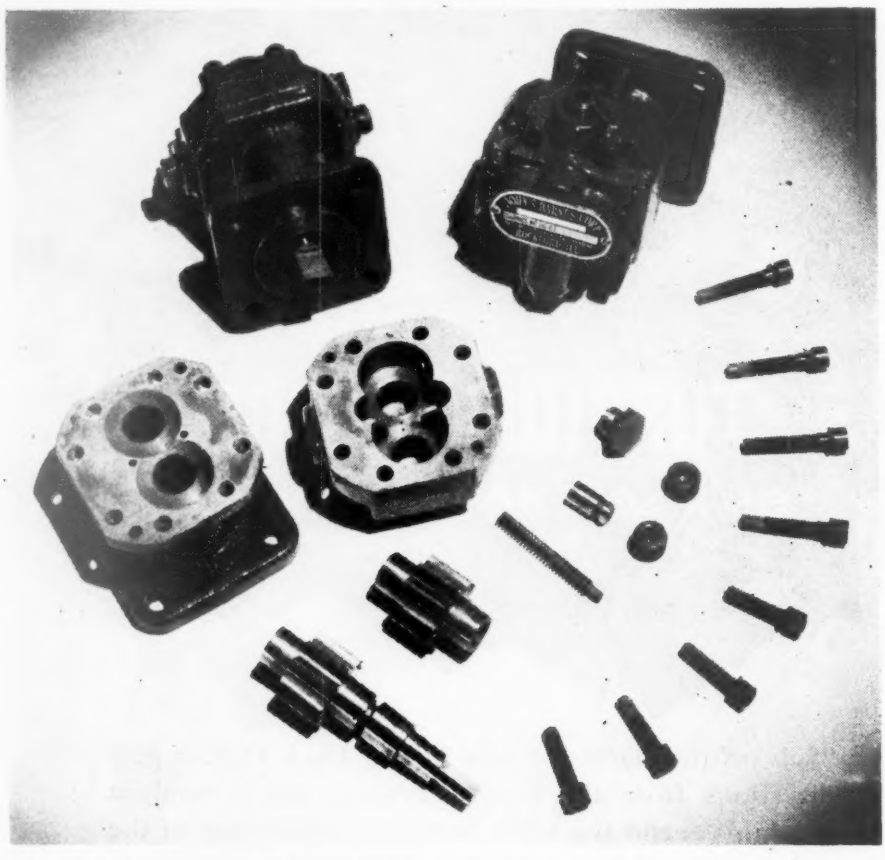
For deep wells and high sulphate resistance, use 'STARCOR'*. In deepest wells, use 'TEXCOR'*, with extra long thickening time, plus high sulphate resistance. Use 'INCOR'* for earlier drill-out in wells of moderate depth — and LONE STAR CEMENT for dependable all-around service. Time-tested performance — backed by continuing oil-well-cement research.

*Reg. U. S. Pat. Off.

LONE STAR CEMENT CORPORATION · DALLAS · HOUSTON

Barnes rotary pump

A new, low pressure rotary pump, which is designed for industrial application and affords an efficient and economical method for pumping all types of liquids having lubricating qualities, has been announced by the John S. Barnes Corporation, Rockford, Illinois. The new Barnes pump is ideally adapted for use as a lubricating booster pump for oil lines, a gasoline dispensing pump and for oil pressure systems on automotive, truck or tractor equipment, the manufacturer states. It has also proved suitable for use on torque converters. Capacity of the Barnes pump ranges proportionately from 1 gal. per min. at 600 r.p.m. to 4 gal. per min. at 2400 r.p.m.



It has a high volumetric efficiency pumping extremely low viscosity fluids.

An outstanding feature of the new pump is the Barnes patented spur gear tooth form. Tooth construction of the Barnes spur gear completely eliminates excessive sliding, and reduces slippage of the fluid to an absolute minimum; each tooth completely fills the mating space, as the gears mesh, and perfect sealing action is effected, it is stated. Thus positive displacement of the fluid is assured despite variation in fluid viscosity or other factors.

Protection against excessive pressures is afforded by a relief valve, which is adjusted and set at the Barnes factory under operating conditions simulating those of the plant in which the pump is to be installed. Complete balance is effected by equalized fluid pressure throughout the pump. The Barnes pump can be supplied with or without relief valve.

The vacuum created by two identical, precision out, spur gears, which are the only moving parts, draws the fluid being pumped through the pump inlet. The fluid then passes between the teeth of the gears to the discharge side of the pump. The meshing of the gears forces the liquid into the discharge line. The driving gear is equipped with a free floating type driveshaft, of fine grained steel, with shear pin to minimize damage caused by foreign materials entering the pump housing. A spring loaded oil seal is used on the driveshaft and the shaft is tanged to fit the power drive slot.

The spur gears, which are made of special alloyed cast-iron, are cast integral with the shaft itself. The shafts are precision machined to bearing limits to rotate in the bore of the pump housing, eliminating the need for bronze or roller bearings, and assuring trouble-free operation and long bearing life. The pump housing is also cast from special alloyed iron.

Self priming is a feature of the pump and all moving parts are self lubricated. The pump is precision machined throughout and can be easily assembled and taken apart; socket head screws are used in assembly. The pump can be bolted onto any machine in positions to suit the power take-off.

The maximum pressure range on the Barnes pump is 200 lb. per sq. in. and tests show that vacuum to 26 in. mercury gauge is feasible.

The following fluids can be handled efficiently and economically by the Barnes pump: Benzine, cocoanut oil, cotton seed oil, essential oils, lubricating oils, mineral oils, naphtha, olive oil, quenching oils, vegetable oils, and turpentine; however, virtually any fluid with lubricating qualities can be pumped.

Light weight and small space features of the Barnes pump may also be used advantageously; weight is 3½-lb. complete.

Fire extinguisher

As it is "Mr. Average Employee" who usually faces the fire, mobility and ease of operation are all-important in combating widespread flames with the heavy duty fire extinguisher.

Keeping these factors in mind, Randolph Laboratories, Inc. of Chicago, Illinois, has produced a 25-lb. wheel-type carbon dioxide fire extinguisher that is moved and operated with uninterrupted, single-sweep action.

The Randolph "25" features an exclusive palm-trigger valve, mounted conveniently on the extinguisher steel handle. By grasping the handle, the operator can move the unit and press the release button with one hand, discharging a penetrating, icy blanket of carbon dioxide in a large, sweeping arc 10 to 20 ft.

Release of pressure on the palm-trigger automatically stops the flow of carbon dioxide gas, eliminates twisting of valves and retains the remainder of the charge for repeated attacks. This simplified operation saves precious seconds and greatly reduces the chances of "operators panic."

The long range 5¾-ft. horn-and-hose connection directs an accurate, full

charge into the base of the flames, and keeps the operator at a safe distance from the heat of the fire. Mounted on hard rubber wheels, the unit is self balanced, standing or in operation.

This unit is especially recommended by the manufacturer for protection against gasoline, oil, paint, grease, machine, electric, and surface fires in shops, shipyards, refineries, garages, airports.

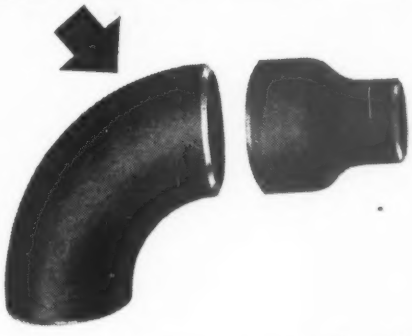
Additional information on carbon dioxide fire-fighting methods may be obtained from the manufacturer, Randolph Laboratories, 8 East Kinzie Street, Chicago, Illinois.

THIS →

IS BETTER

PIPING PRACTICE

Than these Together



Why make three welds when two will produce a better piping job? Where it is necessary to change both the direction of flow and size of pipe, the Midwest Reducing Elbow replaces two welding fittings: (1) a standard elbow and (2) a reducer. The many important features are enumerated at the right.

All the advantages of Midwest Standard Elbows are to be found in Midwest Reducing Elbows: unusual dimensional accuracy and uniformity, beneficial effect of working metal in compression, stress relieving, etc. Center-to-end dimensions are the same as in standard elbows with which they are interchangeable.

The Reducing Elbow is only one of the many Midwest developments designed to improve the quality of welded piping and to save cost in erection. Write for Bulletin WF-41 for complete information about the advantages of Midwest Welding Fittings.

MIDWEST

PIPING & SUPPLY COMPANY, INC.

Main Office: 1450 South Second St., St. Louis 4, Mo.

Sales Offices: New York 7—(Eastern Division) 30 Church St., Chicago 3—645 Marquette Bldg. • Los Angeles 33—520 Anderson St. • Houston 2—229 Shell Bldg. • Tulsa 3—533 Mayo Bldg. • Atlanta 3—Red Rock Bldg. • South Boston 27—426 First St.

• Distributors in Many Cities

MIDWEST

REDUCING

WELDING ELBOW

Eliminates One Weld

Cuts Installation Costs

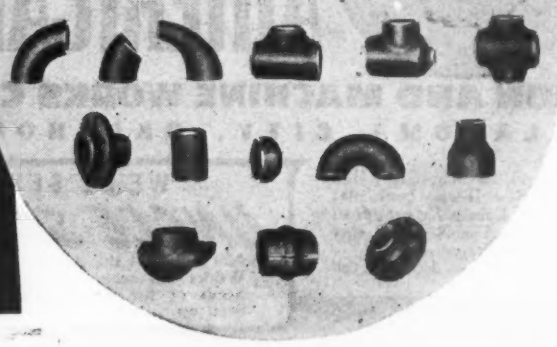
Saves Time

Reduces Turbulence

Improves Appearance

MIDWEST

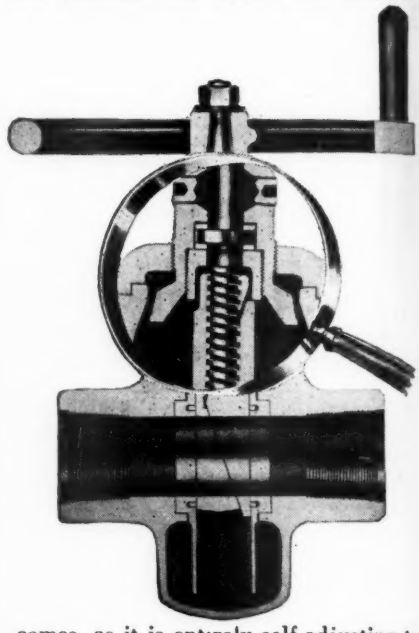
WELDING FITTINGS IMPROVE DESIGN AND REDUCE PIPING COSTS



W-K-M gate valve

A new principle of valve bonnet construction is incorporated in the new steel W-K-M gate valve for general service that has just been announced. In addition to the improved bonnet design, and the body and bonnet of steel rather than iron or semi-steel, this valve has all the exclusive features that have contributed to the success of W-K-M high pressure valves during the past several years, the manufacturer asserts.

The new W-K-M design is a marked departure from the conventional bolted-on bonnet, and requires no flanges, no bolts, and no gland. A perfect seal is effected inside the body, by means of a double tapered ring between similar tapers on the upper inside of the body and the lower outer diameter of the bonnet. In assembly the lower end of the bonnet is inserted in the body and the sealing ring pushed down around the bonnet. Then when pressure is applied, the ring is wedged in place, forming a positive seal; however, no residual load is required to maintain a seal. A threaded protector ring or bridge member, is then screwed on the upper end of the bonnet to complete the assembly. Before the application of this ring, the joint may be inspected under the full test pressure. Thus internal pressure, which tends to push off the conventional bolted bonnet, acts to make this seal more positive. The area of the sealing ring is predetermined and requires no permanent deformation to form a seal. The greater the pressure, the tighter the seal becomes, as it is entirely self-adjusting to pressure and temperature changes.



The bonnet and ring are self-aligning, and a minimum area is exposed to pressure. Because of the elimination of bolted flanges, this valve has fewer parts, considerably less weight, and at the same time provides a great factor of safety.

All exclusive features of the W-K-M high pressure valve are retained: the through conduit, full bore opening entirely through the valve, the parallel expanding gate that assures a positive shut off, the oversize bronze renewable seats that are not exposed to damage or wear in either open or closed position, and automatic lubrication, attained by the utilization of body and bonnet as a reservoir for a generous supply of lubricant, which contributes to ease of operation.

This new model of W-K-M valve is made in both 1600-lb. test pressure and 1000-lb. test pressure. Literature is available from the W-K-M Company, Inc., Houston, Texas.

Slide rule

An exceptional value is a new professional 10-in. polyphase type rule. A, B, C, D, CI, and K scales are on front and S, L, T scales are on the back of the slide. Recess at end has a contact hairline index permitting use of S, L, and T scales without reversing slide.

Markings are clear, easy to read, accurately and finely calibrated on white face. CI calibrations are in red. Sharp hairline indicator is gunmetal framed.

The rule is made of carefully machined hardwood and has smoothly finished edges, and retains accuracy regardless of temperature or humidity. An attractive flexible case and instructions come with every rule.

Lawrence Engineering Service, 513 North Smith Street, Peru, Indiana, is the manufacturer.

Stop paraffin difficulties
with this "American"
PARAFFIN BIT
Use this successful tool for scraping paraffin from casing or tubing! Has four sets of wings, staggered so that whatever paraffin one set misses, another set will pick up. These wings turn up as the bit is lowered—then drop back into scraping-position as bit is raised. The body is double extra strong tubing—hollow, to keep bit from being blown out of hole by gas pressure. Chisel-end at bottom cuts through any hard paraffin which might otherwise stop bit by packing!
Write for complete ★ details now!
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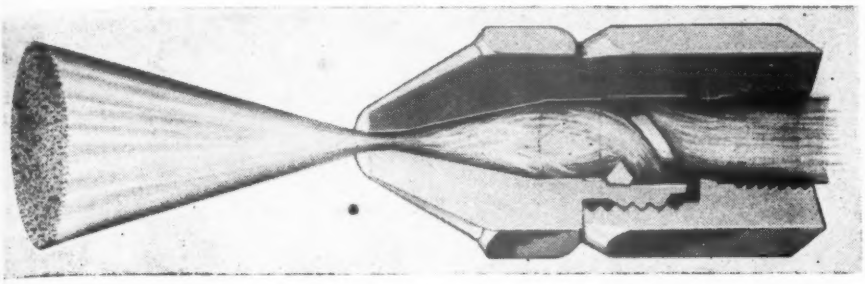
Spray nozzles

In the "Fulljet" spray nozzle, injector type, Spraying Systems Company, Chicago, Illinois, offers the process industry another precisely engineered nozzle built to conform to exact specifications.

The "Fulljet" is made in brass, steel, monel metal, and stainless steel. Removable internal vanes are a construction feature permitting quick, easy replacement.

This nozzle is stocked in a wide range



This nozzle produces a full cone spray pattern at a highly uniform degree of atomization. It is designed for use in gas washers and related process applications. The concentrated narrow-cone "Fulljet" provides a high degree of impact for any given pressure. Where required an efficient syphoning action may be readily obtained. Water and other liquids of similar viscosity may be handled.

of sizes each having definite performance characteristics. For example, if a process requires delivery of a liquid under 40 lb. pressure at a rate of 3 gal. per min. and a spray angle of 30°, a stock size "Fulljet" injector type nozzle may be had to perform in exactly this way. A new technical reference catalog is now available on this and all other Spraying Systems' nozzles.

Galv-Weld process

Taking a tip from the shipbuilding industry, which has been regalvanizing welds in galvanized sheet, plate, and pipe, the petroleum industry quite generally is planning the postwar use of welded galvanized fabrication for products heretofore of riveted or bolted construction, according to George H. Ohmer, chief engineer of Galv-Weld Products, Dayton.

Such all-welded design has been made possible by the patented Galv-Weld Process, says Ohmer, which, in brief, consists of the coating of the weld and the adjacent damaged area with Galv-Weld Alloy at the time of welding. Heretofore, welded galvanized structures have been fundamentally unsound from the corrosion standpoint, since the protective galvanizing burned away at the point of and during the process of welding, Ohmer asserts.

Riveted or bolted construction, not as strong or versatile as welded, has been the conventional means of fabricating galvanized steel towers, frames, bases, and the like, he points out.

Although in commercial service a short time prior to the war, the Galv-Weld Process first attracted national attention when the thousands of welded joints in merchant and fighting ships were regalvanized and made completely rust and corrosion proof. Galv-Welded joints have withstood more than 5 years' exposure in salt air mists.

The petroleum industry has been quick to see the need for Galv-Weld in the maintenance of galvanized refinery equipment, Ohmer asserts. The alloy is not affected by corrosive and acid-bearing fumes in refinery areas.

Readily adaptable to gas, electric, and spot welding, the Galv-Weld Process requires no flux in application and gives off no fumes. The alloy, which comes in bar form, may be applied in all positions and in confined quarters. Once applied, the coating will not chip, crack or peel, it is stated.

Complete details may be had by writing Galv-Weld Products, 393 E. 2nd St., Dayton 10, Ohio.

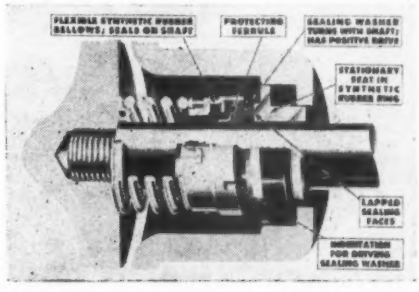
Shaft seal

The new John Crane bellows type shaft seal eliminates stuffingbox leakage and provides perfect sealing on centrifugal pumps, refrigeration compressors, speed reducers, rotary pumps, agitator shafts, and many other rotary sealing applications, according to the manufacturer, Crane Packing Company. It has already been thoroughly field-tested on many exacting services and is giving trouble-free performance at both high speeds and high pressures, it is stated.

The John Crane shaft seal is supplied as a complete sealing unit, ready for use, and is simple and easy to install. Basically, it consists of three major parts: (1) A flexible synthetic rubber bellows, the tail end of which grips and seals along the shaft; (2) a stationary floating seat, held in a synthetic rubber sealing ring; and (3) a positively-driven sealing washer, which turns with the shaft and is held against the stationary seat by spring pressure. The contacting faces of the washer and seat are lapped to form a leakproof seal.

An exclusive feature is the flexing head of the bellows, which offers no resistance to the spring. This design allows the sealing washer to remain in contact with the seat as the sealing faces wear, and provides automatic compensation for shaft vibration and end-play. A protecting ferrule, fitting the shaft loosely, guides the flexing bellows head and prevents the synthetic rubber from contacting the shaft. Note that there is no compression packing to freeze to the shaft and cause trouble.

The stationary floating seat used in most installations is held in a synthetic rubber holding ring as illustrated. This construction permits easy insertion, prevents stress distortion of the sealing face during installation, and allows the face to be lapped before insertion, thus elim-


FLEXIBLE SYNTHETIC RUBBER BELLOWS; SEALS ON SHAFT
PROTECTING FERRULE
SEALING WASHER TURNING WITH SHAFT; HAS POSITIVE DRIVE
STATIONARY SEAT IN SYNTHETIC RUBBER RING
LAPPED SEALING FACES
INDENTATION FOR DRIVING SEALING WASHER

Sectional view of John Crane shaft seal installed in a centrifugal pump, a typical application.

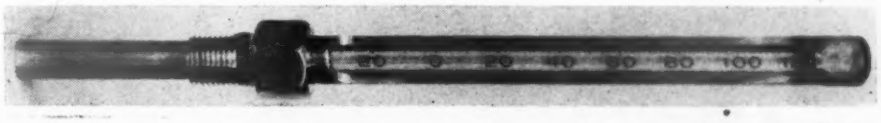
inating the difficulties involved in lapping the face in the seal cavity.

The flexible bellows and holding ring are molded of special high grade synthetic rubber stocks for maximum resistance to oil, hydrocarbons, refrigerants, water, and anti-freeze solutions. The other parts are made of materials best suited to give maximum service and to resist the chemical action of the fluids handled.

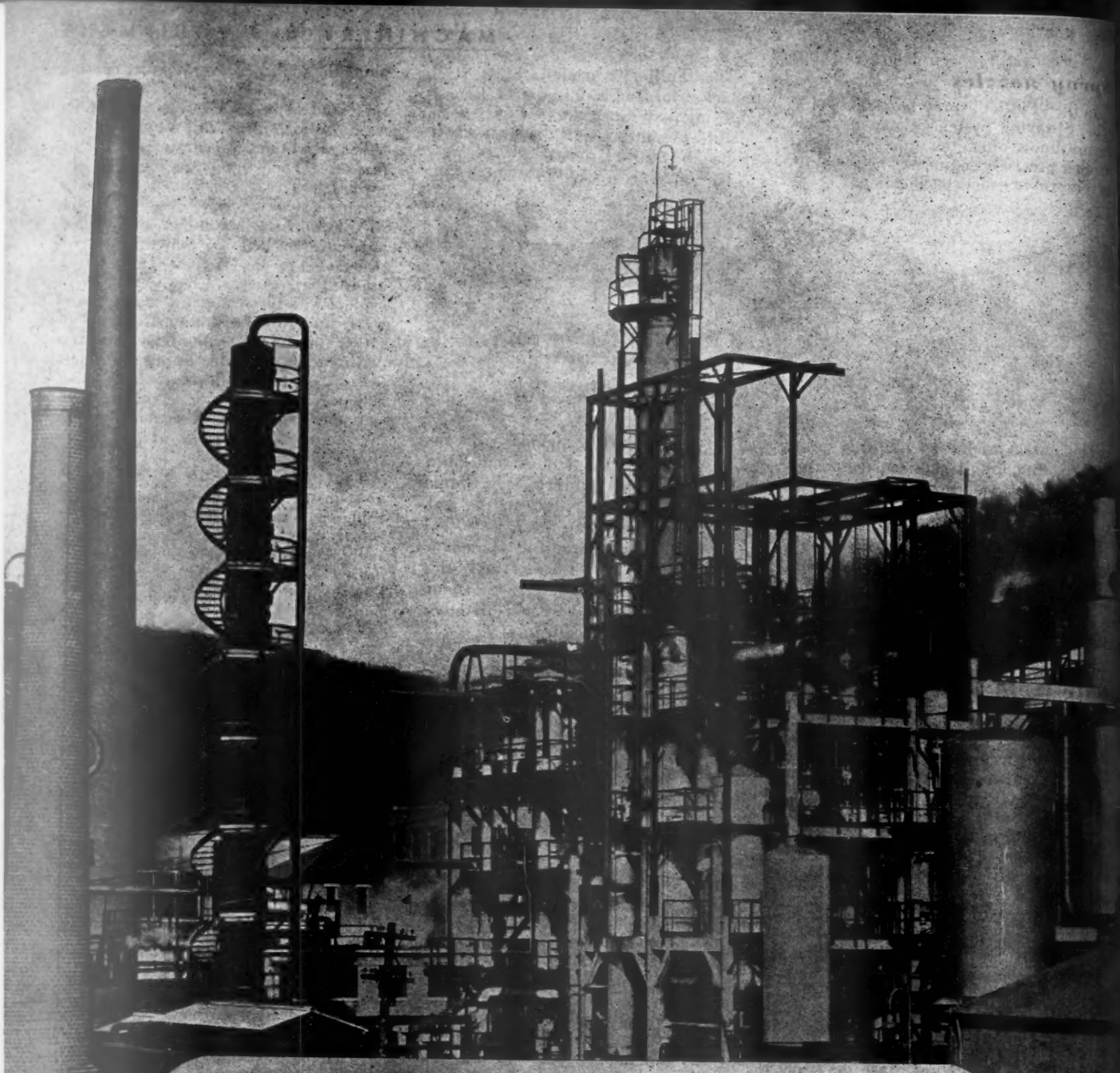
This high-precision mechanical seal is manufactured by Crane Packing Company, 1841 Cuyler Avenue, Chicago 13, Illinois. An illustrated bulletin giving full details is available on request.

H-B midget thermometer

For the last 10 years H-B midget industrial thermometers have been installed where temperature indication must be maintained with laboratory accuracy and where large, heavy thermometers are not suitable. They are used in



distilleries, the synthetic rubber industry, the petroleum industry, in experimental work especially in the electronic industry, and other essential applications. These H-B Midget instruments are easy to read because of lens-front yellow back tube and scale engraved on glass. Scale ranges are varied from minus 30 to plus 700°F. They are made in both straight and angle types, weighing but 5 and 7 oz., respectively; straight type is 9 in. overall. Request descriptive folder from H-B Instrument Company, 2518 North Broad Street, Philadelphia 32, Pennsylvania.



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International trucks

Commercial trucks produced in 1945 by International Harvester under governmental authorization will carry the same model designations and be styled the same as Internationals built in 1942 and 1944 for civilians. In keeping with Harvester's traditional policy of constant product improvement through the incorporation of new design features and new materials as soon as they have been proved by exhaustive tests, these new trucks will embody many new features and improvements, some of which had been contemplated before truck production was stopped by the government in March, 1942. Most of these improvements have been incorporated in various military models the company has produced since that time. It is now permissible under material regulations to make use of them in civilian production. These new civilian trucks will be sold through the regular International Harvester dealer and branch organization to operators whose business requirements place them on the ODT priority list.

Five basic models will be available in the 1945 International line, according to P. V. Moulder, general manager of the motor truck division. These will be produced in a variety of wheelbase lengths and with equipment to meet the requirements of essential users. Production of the popular medium duty Model K-5, several thousand of which were built in 1944, will be continued as will the heavy duty Models K-7 and KR-11. Additions to the line for 1945 will be the light duty K-3 and the heavy duty K-8, also basic prewar models. These trucks have the following gross vehicle weight ratings: K-3, 6650 lb.; K-5, 13,500 lb.; K-7, 16,500 lb., K-8, 20,000 lb., and KR-11, 27,000 lb.

The heavy duty models will be equipped with the more powerful Blue Diamond (K-7) and Red Diamond (K-8 and KR-11) engines. Harvester's famous Green Diamond engine powers the Model K-5. Since, as a result of wartime experience, the trend, especially in heavy duty trucks, is definitely toward more power, the Models K-8 and KR-11 will be supplied with the larger, more powerful optional Red Diamond 361 and 450 engines, respectively.

An improved type of crankcase ventilation will be supplied in the International Red Diamond engines. The value of this ventilation system lies in its ability to reduce the accumulation of crankcase vapors resulting in a highly desirable reduction of sludge so detrimental to engine efficiency. The system includes a metering valve (installed in the oil filler pipe) and a cylinder head breather. The metering valve which is connected by a vacuum line to the intake manifold controls the amount of vapor-laden fumes drawn from the crankcase by the intake manifold vacuum. The cylinder head breather filters the air being drawn into the engine through the valve rocker arm compartment. Operation of the crankcase ventilation system consists, therefore, in drawing cleaned air into the engine and, as previously stated, withdrawing the fumes from the crankcase. For some time this ventilating system has been employed with excellent results in Red Diamond engines, which power certain military trucks and half-track vehicles produced by International Harvester.

The Models K-7 and K-8 are equipped with hydraulic brakes with the recently perfected hydrovac vacuum-power system whereas the KR-11 has air brakes. The hydrovac will be available on the K-5 and air brakes on the K-8 as special equipment at extra cost.

K-8 and KR-11 power plants will be equipped with an especially efficient mechanical vacuum type governor that has the control characteristics and advantages of the mechanical type governor without the complications of the mechanical drive system. This governor is used in unit with a new and improved duplex type (two venturi instead of one) downdraft carburetor. Several years of engineering laboratory and road tests have shown this new set-up to have a remarkable record of consistent operation on these large engines, which it is desirable to govern very close to the horsepower peak.

All International medium and heavy duty models to be produced for civilian service in 1945 will be available with two speed as well as single speed rear axles. These will be designated as Models KS-5, KS-7, KS-8, and KS-11. These trucks will be equipped with vacuum controlled shift mechanism for the two speed axle. A small button attached to the transmission gearshift lever, easily within finger tip reach when the hand is on the transmission shifter lever, controls the low and high axle speeds, thus all transmission ratios and both axle ratios are immediately available for the driver's choice. All shifts are on one lever. There are only two positions for the control button. When the button is in the lower position the axle is in the low ratio and the truck is a powerful low speed truck that will operate in all transmission ratios. When the button is in the uppermost position, the axle is in the high ratio and the truck is a high speed vehicle that will operate in all transmission ratios. This simple, quick, and positive axle shifting device provides for the best use of the wide range of final drive ratios available in trucks having two speed axles.

A cast-steel housing for the KR-11 rear axle provides greater rigidity and strength than the malleable housing formerly employed. Other refinements in the International line for 1945 will include the forged tocco-hardened camshaft in the Blue Diamond (K-7) engine, oil-filled ignition coils on all models, new and improved battery mounting under left-hand cab skirt on the heavy duty models, a heavy duty starting motor housing on the Red Diamond engine, etc.

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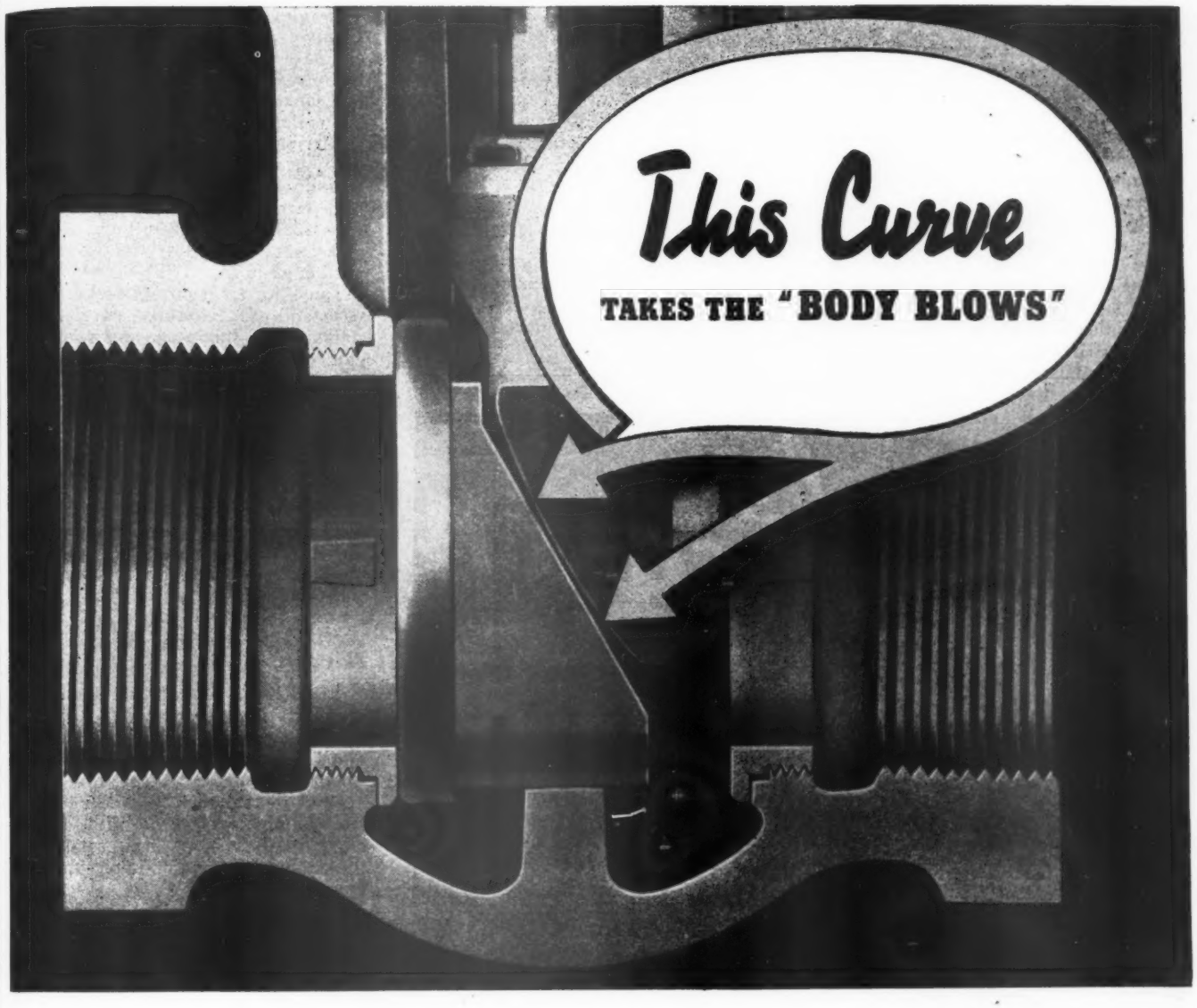

LINE strains, high temperatures and pressures will distort the body of any valve. Only Darling fully revolving double disc parallel seat gate valves have the curved wedge face and transverse bevels that permit the gate to adapt itself to out-of-line positions the valve seats may assume. There's no need to jam or force it; it fits naturally, easily and tightly.

The valve assembly consists of four simple parts—two discs, two wedges. These can easily be removed for inspection or maintenance without taking the valve from the line. When the valve closes, the two wedges force the discs firmly against the valve seats. On opening, the first quarter-turn instantly releases the wedges and frees the discs to be raised with less seating wear

The discs are fully revolving through 360° and seat themselves in a different position each time the valve is closed. Thus wear on disc and seat is uniform, and life-long, tight closing results.

For drop-tight closing, year after year, for long, economical, trouble-free service, specify Darling Valve.

TRADE DARLING MARK VALVE & MANUFACTURING CO.
WILLIAMSPORT, PA.

Airco Hi-Bond flux

The Air Reduction research laboratories have developed a flux designed to promote uniformly successful tinning of cast-iron prior to brazing. The manufacturer states that this flux, known as Airco Hi-Bond, overcomes the difficulties encountered in tinning cast-iron due to its graphitic nature and makes possible highly satisfactory tinning of cast-iron especially of high carbon and silicon content or low combined carbon analysis.

The flux does not take the place of the regular flux used for the actual brazing operation. Hi-Bond flux may be applied as a water-mixed paste or as a powder sprinkled on the surface that has already been heated to the required temperature. It is packed in 1-lb. glass containers and is available from Airco offices and distributors throughout the country.

Additional details may be obtained by writing to the manufacturer, Air Reduction Sales Company, 60 East 42nd Street, New York 17, New York.

Synthetic rubber tanks

Portable synthetic rubber tanks are now extensively used in combat areas for the transportation and storage of gasoline, oil, and aromatic fuels, and to insure an adequate supply of these vital materials at all times.

Developed by United States Rubber Company, these huge collapsible tanks can be set up or taken down very quickly. Advantages of the synthetic rubber fuel tanks for overseas use are that they are collapsible and can be shipped in small space. They are light in weight, easily camouflaged in the field, and can be quickly set up or knocked down for transportation to a new location by a very small crew. Before their use, steel tanks were needed for storing or transporting gasoline.

Tanks for transporting fuel are made with 750-gal. capacity, carried on a standard 2½-ton truck and with 2700-gal. capacity, three of which are carried on one railroad flat car.

Storage tanks, used for advance combat or reserve supply back of the lines, will hold either 1000 gal. or 3000 gal. of gasoline.

The collapsible fuel tanks are made of mildew-proofed fabric coated with two types of synthetic rubber, one with a low diffusion rate and the other with high adhesive qualities. Tanks must withstand heat up to 165°F. and cold to zero.

Rivnut

The Rivnut, the blind fastener that serves as a nut-plate, rivet or both, is now being made of brass as well as aluminum, it is announced by The B. F. Goodrich Company, Akron, Ohio, developer of the product. Tensile and shear strength of Rivnuts made with the brass alloy are about 50 per cent greater than those made from aluminum, the company says.

The Rivnut was originally developed for aeronautical uses, its first application being the attachment of the De-Icer, made by B. F. Goodrich, to aluminum wings. Other aircraft industry uses followed.

With demands for the Rivnut from the aeronautical industry being satisfied, the fastener has been adapted by other industries.

Boring and reaming blades

Boring and reaming blades made of Haynes Stellite cobalt-base alloy are available from Haynes Stellite Company, a unit of Union Carbide and Carbon Corporation, Kokomo, Indiana.

Haynes Stellite boring blades are used for rough and finish boring operations on cast iron, malleable-iron, brass, and bronze, and for rough and semifinish boring operations on steel. Haynes Stellite reamer blades are used chiefly on cast iron, although they have been successfully used on malleable iron, brass, and bronze. They are not recommended for finish-reaming steel.

Haynes Stellite alloy boring and reaming blades are available in two grades: 98M2 and Star J-Metal, with Haynes Stellite 98M2 especially recommended for boring steel. They are supplied to users' specifications, finish-ground to required tolerances. Further information about these blades may be obtained from Haynes Stellite Company, Kokomo, Indiana.

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SALT WATER DISPOSAL IN EAST TEXAS

EXCLUSIVE

Production statistics. The oil produced in the East Texas field varies in gravity from 38° to 39½° API. The color of the oil is green to greenish black. The darker oil is usually found on the west side. The Saybolt Universal viscosity is 40 sec. at 100° F. By distillation test 35.8 per cent of the crude is gasoline or lighter and only 52 per cent is boiled off up to a temperature of 527° F.

The East Texas field was discovered September 5, 1930, by Joiner-Bradford No. 3 located in the Ximines Survey, in Rusk County. The field was extended rapidly by other wildcats. The second well, Bateman-Crim No. 1 in the Sevier Survey of Rusk County completed December 28, 1930, extended the field 10 miles northward. The next extension well was completed January 26, 1931, on the Lathrop lease 14 miles northeast of the Bateman well.

The rapidity of development is indicated by the following table:

Date	No. wells producing
Jan. 1, 1931	5
Jan. 1, 1932	3,612
Jan. 1, 1933	9,372
Jan. 1, 1934	11,875
Jan. 1, 1935	15,507
Jan. 1, 1936	19,506
Jan. 1, 1937	21,960
Jan. 1, 1938	24,269
Jan. 1, 1939	25,765
Jan. 1, 1940	25,977
Jan. 1, 1941	25,921
Jan. 1, 1942	25,820
Jan. 1, 1943	25,483
Jan. 1, 1944	25,100

FIG. 17

CHAPTER I—SECTION C
Production History of THE EAST TEXAS FIELD

The slow rate of well depletion is shown by the well abandonment rate:

Year	Number of producers abandoned
1932	2
1933	6
1934	10
1935	12
1936	18
1937	97
1938	195
1939	265
1940	372
1941	577
1942	329
1943	388

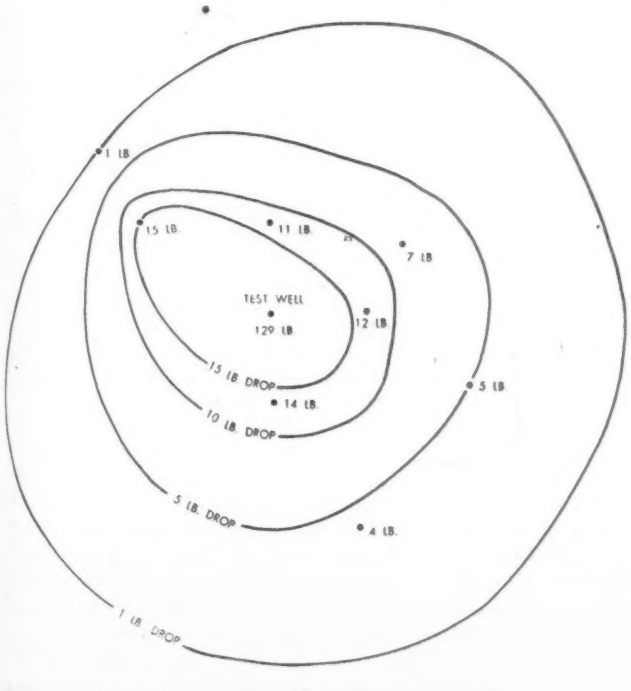
Early wells were produced wide open with storage space as the only limiting factor. The first proration order was issued by the Railroad Commission to be effective April 10, 1931. It divided the field into three areas: Henderson, Kilgore, and Longview. The daily allowable was fixed at 90,000 bbl., which was to be divided among the wells on an acreage and potential basis. Potentials were to be based on a three hour test made on an 11/16 in. choke through 2½-in. tubing, or on pumping wells at a maximum of twenty-two 72-in. strokes per min. through 2½-in. tubing. No record of an individual well proration schedule can be found. Test data are not available. It is known, however, that a few wells were tested under this order.

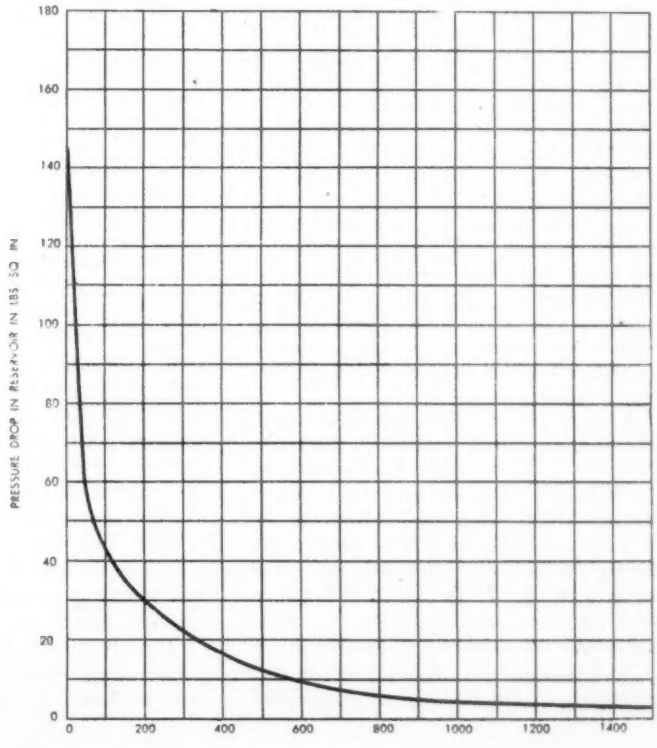
The original order was amended by orders effective April 25, 1931, and May 1, 1931. Each of these orders specified the same requirements for potential tests, but few tests were made as some of the operators were uncooperative and some even refused to allow proration officials on their leases. This condition resulted in the abandonment of a potential factor for the time. There were many proration changes from that time until April 6, 1933. Most of the changes resulted from attempts by the commission to make its rulings conform to court orders. After a court decision that flat per well allowables were illegal, the field was shut in and potential tests made of key wells. The allowable was then based on 15 per cent of the hourly potential as indicated by the potential map. Proration has remained as a per cent of the hourly potential from that time to the present except for the period from September 14, 1939, to June 22, 1940, when a combination per well, acre-foot of sand, and bottom hole pressure formula was used as a result of the Rowan and Nichols case.*

Although orders were issued earlier as recounted above, real enforcement of proration began in September, 1931. The 225-bbl. per well allowable in effect then was gradually revised downward to 36 bbl. per well in March, 1933. The allowable was then based on 15 per cent of the hourly potential effective April 4, 1933, and the percentage was gradually reduced to the 2.32 per cent now in effect.

Early potential tests were made with regular well equipment, but later it be-

FIG. 18





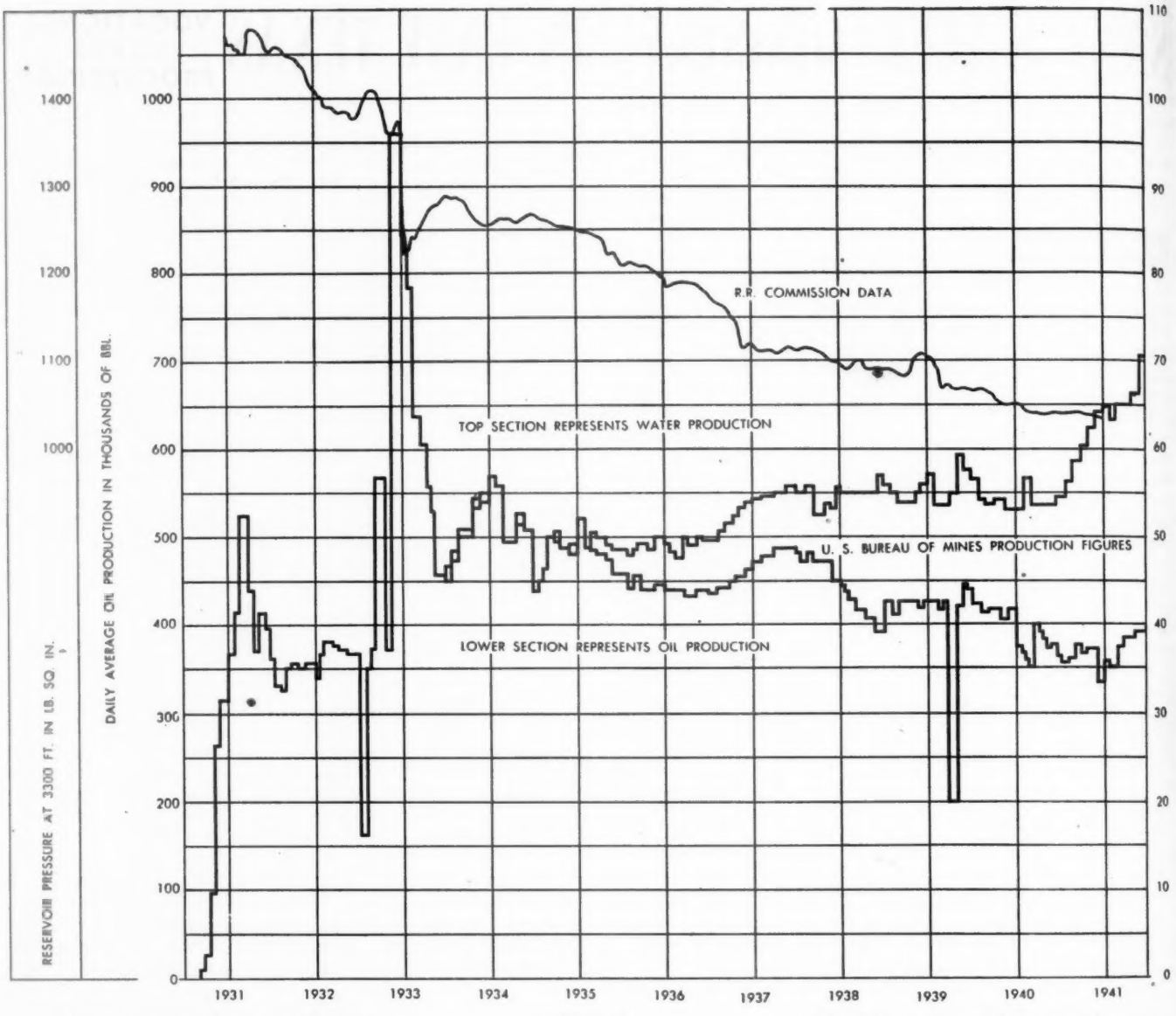


FIG. 19

came the practice to drill special wells and install special equipment to obtain high potentials. Tanks were set right at the well and streamlined flow arms were used to reduce friction. The highest potential ever officially gauged in the field (1119 bbl. per hr.) was made on a well drilled in by circulating oil to avoid the plugging effect of a water base mud on the sand face. Many operators made flowing bottom hole pressure tests in order to calculate the productivity index before deciding to install the special equipment for a potential test. Money spent in obtaining high potentials has been repaid many times over by the increased allowable obtained over a number of years.

As operators realized the harmful effect of open flow potentials on the reservoir, particularly in areas underlain by water, much work was done on methods of estimating potentials by flow at reduced rates. Potential tests were made through tubing only and attempts were made to work out the relation between these and wide open flow tests. No correlation was obtainable due to differences in well equipment. Many present day potentials in other fields are calculated from flowing bottom hole pressure data and all Texas gas well potentials are calculated in this manner. Open flow potential tests have been almost entirely abandoned for proration purposes as the industry has come to realize the cost of the tests both in equipment and reservoir energy.

Estimates of the original oil in place for the East Texas field generally agree on a figure of about 5½ billion barrels. The percentage of this oil to be ultimately produced depends upon how the reservoir is handled. Some experts have estimated that over 80 per cent of that amount could be recovered if the production rate were controlled and that less than 60 per cent would be recovered if the production rate were not controlled. The difference amounts to over a billion barrels of oil and is well worth our attention as well as that of the operators and the regulatory authorities.

The Railroad Commission is well aware of the sharp decline in reservoir pressure at high rates of withdrawal. The following was taken from the proration order of April, 1939:

"Whereas, the Railroad Commission of Texas find from evidence submitted . . . that the reservoir of the East Texas field has its energy supplied by a hydrostatic drive which encroaches from the west to the east and only a certain amount of crude oil can be withdrawn daily from the East Texas Reservoir in order to utilize to the greatest extent the energy necessary for the production and recovery of the greatest amount of oil ultimately from the reservoir. It has been recommended to the commission by competent engineers that not more than 425,000 to 450,000 barrels of crude oil should be allowed to be produced from the East Texas Reservoir in any one day in order that the reservoir might be depleted with the least possible amount of waste incurring. Evidence has also been submitted to the commission at these hearings that the production of from 425,000 to 450,000 barrels of crude oil will prohibit the coning of water, the uneven encroachment of water, and the subsequent trapping of much oil which otherwise, under higher daily allowables of crude oil, would not be recovered."

Production of the East Texas field to March 1, 1944, including estimated "hot oil" was approximately 2 billion barrels.

The U. S. Bureau of Mines production figures by years are as follows:

Year	Total bbl.	Daily average bbl.
1930	27,000	----------
1931	109,561,000	300,200
1932	121,449,000	331,800
1933	204,954,000	561,500
1934	181,540,000	497,400
1935	176,859,000	484,500
1936	167,512,000	457,700
1937	170,673,000	467,600
1938	152,116,000	416,800
1939	144,615,000	396,200
1940	141,023,000	385,300
1941	132,586,000	363,300
1942	120,269,000	329,800
1943	132,113,000	362,000

Gas—The East Texas oil is undersaturated with gas, which is to say that it contains less gas than the oil is capable of dissolving at conditions of reservoir pressure and temperature. This seems especially odd in view of the many Woodbine gas fields where very little or no oil occurs in conjunction with the gas. Approximately 330 cu. ft. of gas are given off by each barrel of oil that reaches the surface. The gas does not begin to come out of solution until the pressure is lowered to 775 lb. per sq. in., abs., and appreciable quantities of gas are not released until the pressure is lowered to about 150 lb. per sq. in. Bringing the oil to the surface pressure and allowing the dissolved gas to escape causes the oil to shrink to 79 per cent of the volume it occupied in the reservoir. All East Texas field wells produce with almost the same gas-oil ratios and from the standpoint of reservoir behavior gas production has never been a problem.

Water—Water production is very important in any oil field because water is expensive to lift. Then after paying the high cost of raising it to the surface the operator is faced with the problem of disposing of it. This problem is so great that it has brought this course of study to you. The Woodbine sand is estimated to contain approximately 4 trillion barrels of water which exerted a hydrostatic pressure of 1620 lb. per sq. in. upon the oil trapped in the East Texas field at the time of its discovery. Water production began as wells were drilled into the underlying water in exploring for the western limit of the field. Approximately 50 per cent of the area of the field lies east of the contact of the original water level and the base of the Woodbine sand. Wells in this area found the sand entirely oil saturated, whereas wells farther west found the sand water bearing below 3320 ft. subsea. Wells bottomed near this depth soon made water as the water invaded the oil-bearing zone to replace the oil being produced. The depth at which wells make water is closely watched in order to follow the position of the advancing water front and be able to predict flowing life of wells, estimate reserves, and plan remedial work.

The permeability of the sand limits the rate of water influx into the reservoir to replace the oil and water withdrawn. It is therefore necessary to restrict water production or to replace produced water in order to maintain the maximum rate of oil withdrawal. The importance of water production was realized early in life of the field and many operators were alarmed at the water production of 15,000 bbl. per day in 1935. However, nothing was done to solve the water problems until late in 1938 when water production had increased to approximately 140,000 bbl. per day.

The following tabulation shows estimated water production:

Date	Avg. water production per calendar day, bbl.
January, 1934 . . .	10,000
January, 1935 . . .	10,500
January, 1936 . . .	18,000
January, 1937 . . .	40,000
January, 1938 . . .	105,000
January, 1939 . . .	115,000
January, 1940 . . .	140,000
January, 1941 . . .	254,000
January, 1942 . . .	388,000
January, 1943 . . .	341,000
January, 1944 . . .	404,000

A comparison of this with the average daily oil production figures shows that water production has exceeded oil production since 1942. * * *

(To be continued in an early issue)

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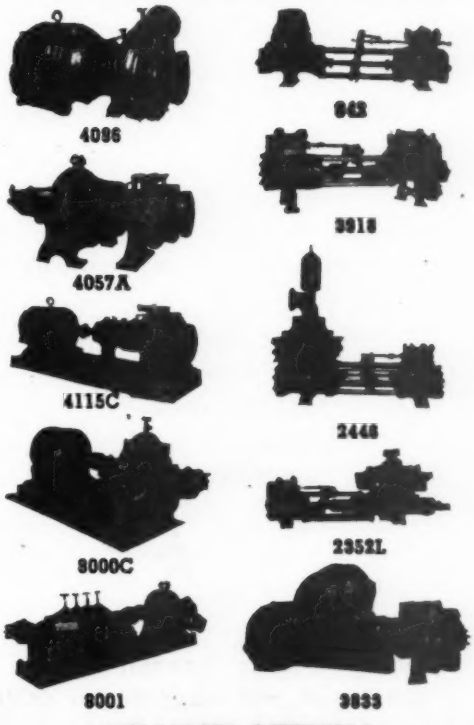

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OUR SCORCHED EARTH POLICY

By **JAN VAN DE VELDE**

EXCLUSIVE THE day the Japs landed at Sourabaya, Java, the island's second largest city, I evacuated. First by troup train to Tjilatjap, then by boat, one of the last incidentally to leave the island, to Australia. From there I came to the United States, took my aviation training, and by the time you read this I will be back in Australia, I hope on my way to Java. I have two jobs to do there. One, some scores to even with the Japs, and after that the almost bigger job of reconstruction.

Before the Japs landed in the Netherlands East Indies, and as they were landing, the "scorched earth policy" was carried out with professional thoroughness. Each phase and detail had been planned long before the actual landing. When we received word of the sneak attack against Pearl Harbor, and final news of the fall of Hong Kong, we all had a feeling that regardless of our efforts, the ultimate result would be complete invasion. We were a brave people then. "We would fight to the last man," we said, and we meant it. Exactly that. But nevertheless we had the feeling that the cards were stacked against us and that the Japs would land.

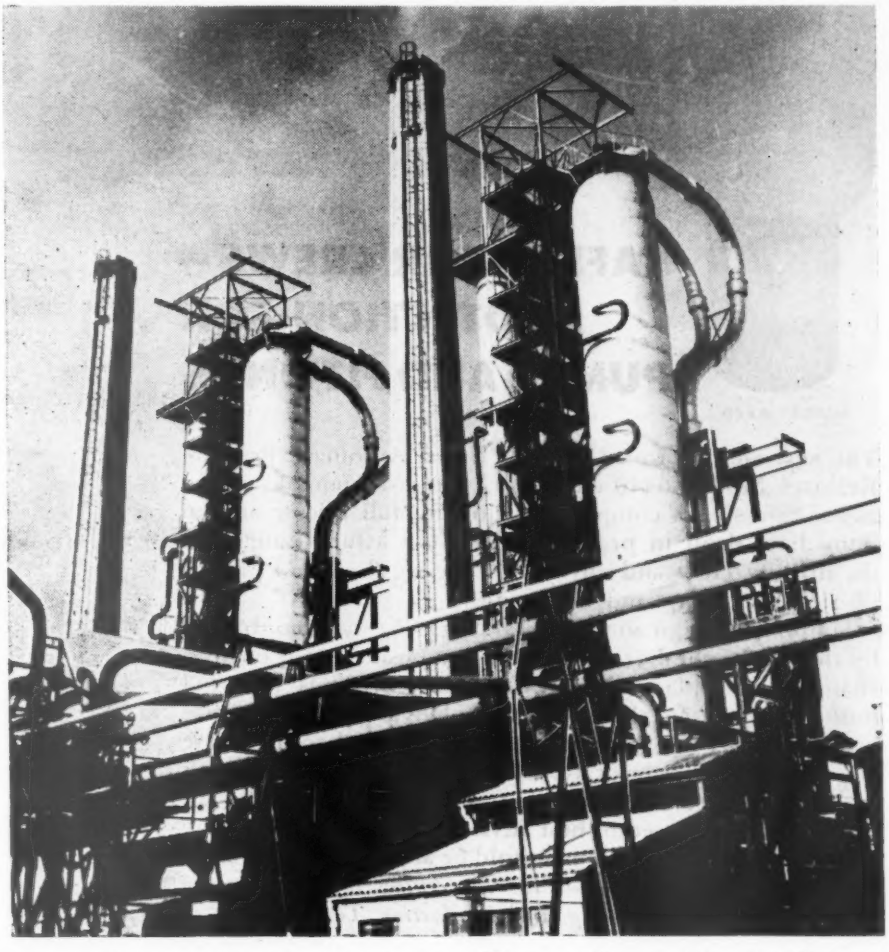
It is hard to explain how you feel when an advancing enemy is near to your home. For a time we had faith in our Navy keeping off the invaders. But those hopes went with the defeat in the battle of the Java sea. I think the action and policy could be best described by saying that with one hand we built defenses and worked toward protecting what we had, while with the other, the more realistic hand, we went about destroying what we knew would be of value to the Jap.

In no field of industry was the scorched earth policy applied with such thoroughness as in the oil fields and at the refineries and with pipe lines.

You can depend on it—the Japs will obtain little oil from the Netherlands East Indies for some time to come. Most of the wells were demolished or rendered totally useless to the enemy. Drilling equipment and machinery in the oil fields was destroyed. Steel derricks were blown to fragments as though they had been made from children's mechanical toy sets. Reels of wire cable either were sunk in the sea or otherwise destroyed. Pipe lines were torn out. Stores burned.

Most of the refinery centers were wrecked. With the exception of a small part of the Pladu, a Java refinery center, I would say that destruction was 95 per cent. At Pladu the Japs used paratroops, swarms of them, and landed far enough ahead of the invasion to prevent total destruction.

In comparison with your oil centers in Texas, California, Oklahoma, Kansas, etc., our production is not impressive. The Dutch oil properties (Royal Dutch Shell) in British North Borneo, Sarawak, and Malaya have a fairly large



Above, modern cracking installation of Dutch Shell refinery on Sumatra, Netherlands East Indies. Left, pipe lines connecting Palembang harbor with the oil wells of the Royal Dutch Shell at Pladjoo. Note labels on pipes.

Editor's Note: Jan van de Velde is a civil engineer. He took engineering training in Amsterdam and went directly to the Netherlands East Indies, to Batavia, Java. In the Indies he engaged in the construction business for the Dutch Government, for plantation owners, railroads, mining companies, sugar refineries, and oil producers. He knows the problems of the Netherlands East Indies. He also knows the Jap.

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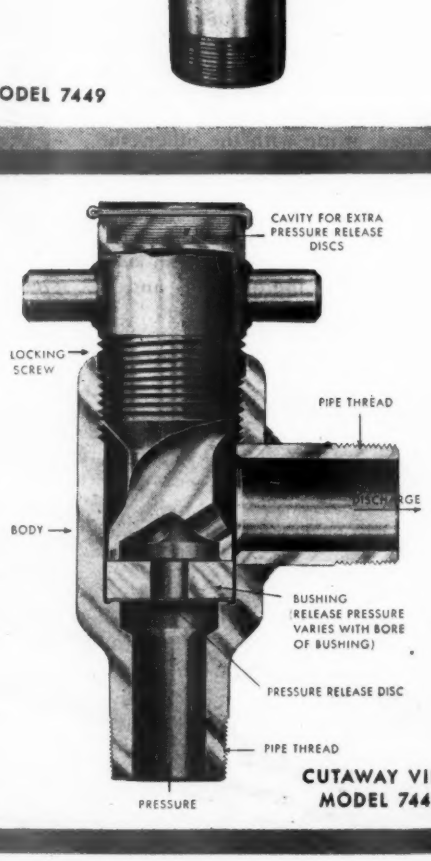

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production record. In the Netherlands East Indies, based on figures for the year of 1939, crude oil production reached 17,487,126 lb. If my 95 per cent estimate on destruction is correct, this would leave less than a million pounds production annually after the scorched earth policy.

When I say the Jap will obtain little oil for some time from these properties in the East Indies, I am basing my opinion on several facts besides the thoroughness of destruction.

The Japanese have had very little experience with oil production. They have too few well trained technicians to throw into the gigantic task of trying to salvage what remains in shambles, or developing potential reserves.

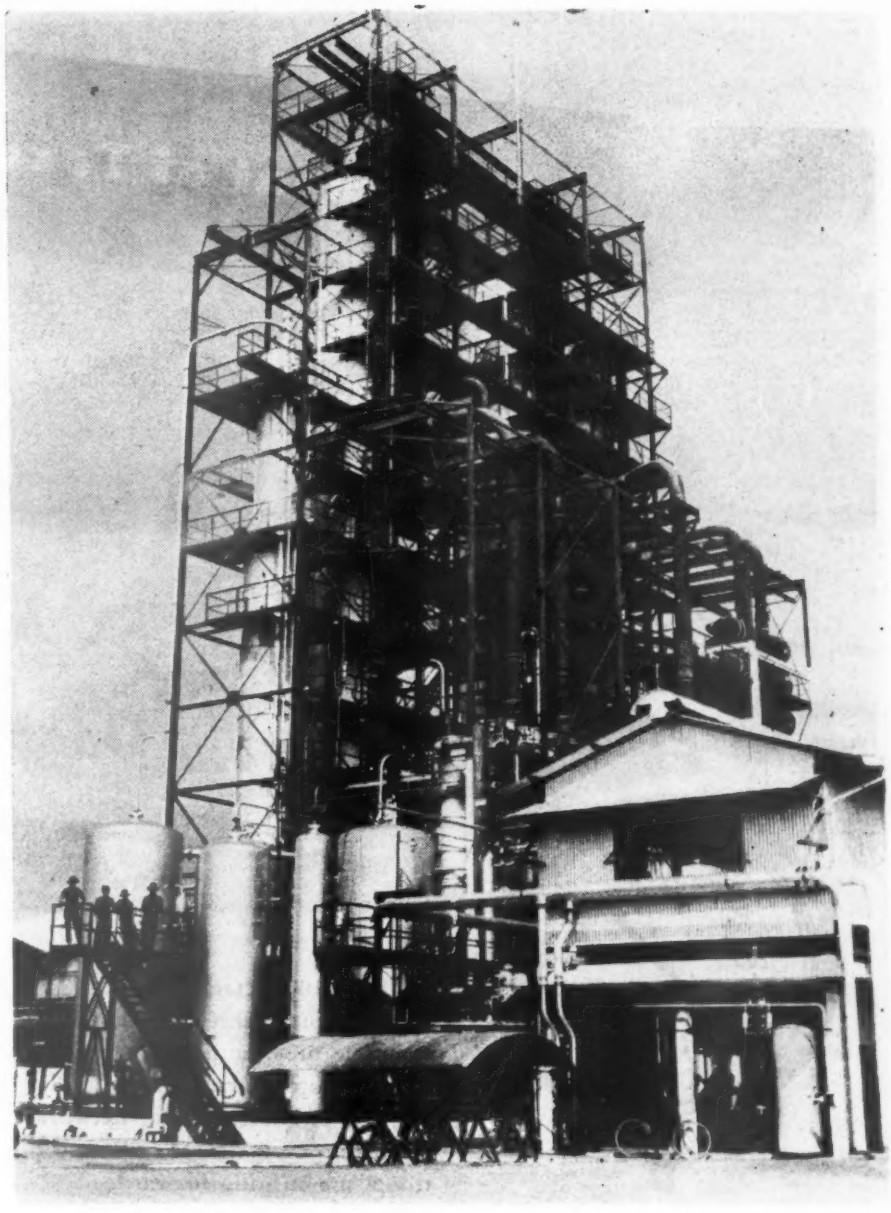
EVEN if German experts agreed to go down to the South Pacific, so long as the Allied air force continues to operate there the prospect for restoration is not promising. Frankly, I do not believe that the Germans sent their trained men into the Pacific. They were needed too badly in Europe. With the invasion, this condition of local need has been intensified. I know the Germans fairly well, also. They would supply experts only if it meant oil for the Germans.

Take a look at your map of this section of the Pacific. Begin with Australia, and with your finger trace along over Papua, Celebes, Borneo, Java, and Sumatra. Go slowly and you will recognize names you are hearing daily over your radio and reading in your news reports. Spots where the Allies have landed or are continually pounding from the air and by warship concentration. This condition is not conducive to a restoration policy.

Another serious drawback for the Jap is the matter of finding usable replacements. The bulk of the destroyed equipment was of the highly specialized type. Most of it came from the United States. The Jap received, up to the very beginning of the war in the Pacific, hundreds of thousands of tons of equipment, but the amount of oil well equipment was very small.

Still another handicap is the transportation hazard. Look again at the map of this section. Allied fleets are constantly operating in waters surrounding these islands, and the lanes leading to them. If replacements units were available and trained experts to make such installations as would be required, it is very doubtful whether sufficient deliveries could be accomplished. In any attempt to picture what is going on in the Netherlands East Indies, it must be remembered that the Allies have in operation in that section the largest navy in the world.

Let us look ahead a year or so. Suppose in that time the Allies are able, in their progress towards Tokyo, to complete the reconquest of the Netherlands East Indies and drive out the Japs. It will be to the advantage of the united war effort to open up the oil fields and rebuild the pipe lines and refineries. Most of the material and equipment will come from United States.



One of the great refining installations of the Bataafsche Petroleum Maatschappij near Palembang on South Sumatra. This and the pipe lines and cracking plant shown before have all been destroyed.

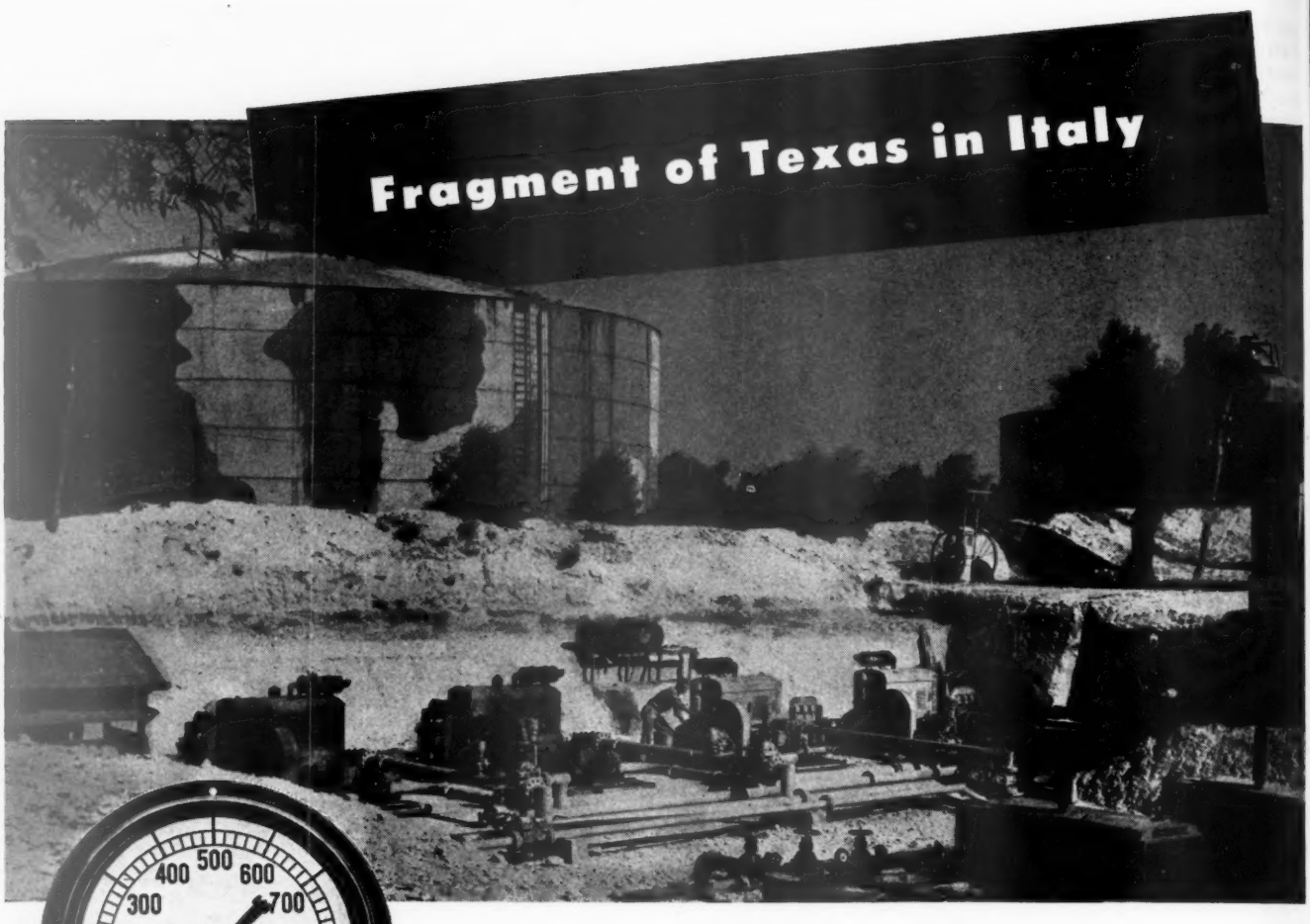
I say this because most of the equipment did come from America and Germany and Japan when the property was first developed. For the Dutch East Indies, the two-from-three-leaves-one deduction is a very fortunate one. Our engineers are familiar with American equipment. We are acquainted with the names of towns in Texas, Oklahoma, and Pennsylvania, as well as phrases such as "working barrels" and "preformed cable." For example the new preformed type wire cable was introduced into the Netherlands East Indies by an American steel cable company. It was found that the trained preformed cable, besides lasting longer, was much easier for the native workmen to handle. Because it was trained, it took less breaking in to accomplish the same result.

The same thing that holds true for cable goes on down through the material and equipment field. American machines and tools and products are better. They are easier to operate. Easier to understand. Take road machinery, cranes, sugar refinery equipment, mine machinery; and the listing could go on for a page.

It will be no easy job — this reconstruction after reconquest. The scorched earth policy was applied with such thoroughness in the oil producing sections of the Indies that it is a serious doubt whether even 5 per cent of the original production remains. The job will be an easier one for us than for the Japs, true, but we will have to begin from the ground up.

I hope that the East Indies oil fields can be reopened before the final conquest of Japan proper. It will be a tough job and require expert timing, but it can be done. I hope it will be done with the better, safer, and easily handled American-made equipment. And—I hope I will be there to help do it. ★ ★ ★

Fragment of Texas in Italy



These 100 octane storage tanks and pumping units are part of a complete pipeline network that has been set up "somewhere in Italy" . . . and of course similar networks reach into every theatre where U.S. troops are surging forward.

Except for the camouflaged tanks, the typical retaining embankment, and the G.I. garb on the men in charge, this picture could have been taken in Texas. As a matter of fact, this and similar systems were installed by an engineering company largely made up of veteran Texas and Oklahoma "oilers".

And right there you probably have the basic reason for the incredible feats that U.S. arms are achieving all over the world. Each task is carried out by an integrated unit of U.S. equipment, methods and men, transplanted to the exact spot where it is needed—in this case Texas transplanted to Italy!

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NATURAL GASOLINE TRENDS CITED AT C. N. G. A. MEETING

By **JOHN H. KUNKEL,** Refinery Editor

EXCLUSIVE MEMBERS of the California Natural Gasoline Association celebrated their 19th annual fall meeting in Los Angeles on October 13 and heard a series of technical papers presented and an industry trend-citing address by C. E. Webber, chief, natural gasoline section, PAW. C. D. Gard, association president, was in charge with M. L. Arnold, Richfield Oil Corporation, presiding at the morning session and O. C. Field, O. C. Field Gasoline Corporation, as chairman of the afternoon session. The association's annual banquet was held in the evening.

In his address Webber reviewed the wartime accomplishments of the natural gasoline industry in California and elsewhere, commented on its expansion and production, made a plea for increased pressure maintenance, cited the natural gasoline industry's role for the remainder of the war, and pointed to its possible postwar position.

Webber stated that the industry's production of light liquid hydrocarbons has reached an all time high, nationally, of over 280,000 bbl. per day, which is twice that of the prewar period. This was accomplished by hundreds of construction projects ranging in size from several times that of California's new Paloma plant down to the installation of minor pieces of equipment. That this expansion is the greatest in the industry's history was emphasized by the statement that, today, there are 30 major plants or plant additions now under construction that represent an aggregate total cost in excess of $30,000,000 and that all 30 projects are industry financed.

Speaking specifically of California, Webber pointed out that this section has increased its daily average production of natural gasoline and allied products from a prewar level of some 41,000 bbl. per day to more than 52,000 bbl. per day at the present time and that this increase was achieved here without the benefit of newly discovered fields and the undeveloped condensate resources of the southwest.

Again discussing the national picture, Webber made it clear that, in spite of this record, production still is not at the level required to continue the war at an accelerated pace and said that one of the major problems confronting the entire petroleum industry today is to spread the insufficient supply of light hydrocarbon fractions thinly enough in some places to allow all essential requirements to be met. This year the customary summer peak of natural gasoline stocks was imperceptible and this fact makes it apparent that many refiners will have difficulty this winter in meeting minimum volatility requirements for both 80-octane all-purpose military fuel and for civilian motor gasoline. However, he said California is in a more fortunate position in regard to these light components than any other section.

▸ **V-E day not to ease pressure.** Many natural gasoline operators have felt that the defeat of Germany would ease the pressure on producers. Authorities in Washington have made a special study of the situation and Webber stated that they cannot share this view. Rather, he said, there appears to be nothing in the ending of the European war, either now, during the winter or next spring that will appreciably alter the course of the natural gasoline industry in California or elsewhere.

It is expected that the shift in the war's emphasis to the Pacific theatre will result in a temporary reduction in petroleum requirements but the magnitude of that reduction cannot now be stated. Speaking of natural gasoline industry's position at that time, he pointed out that the demand for natural gasoline and cycling plant products will not then decline as some might expect.

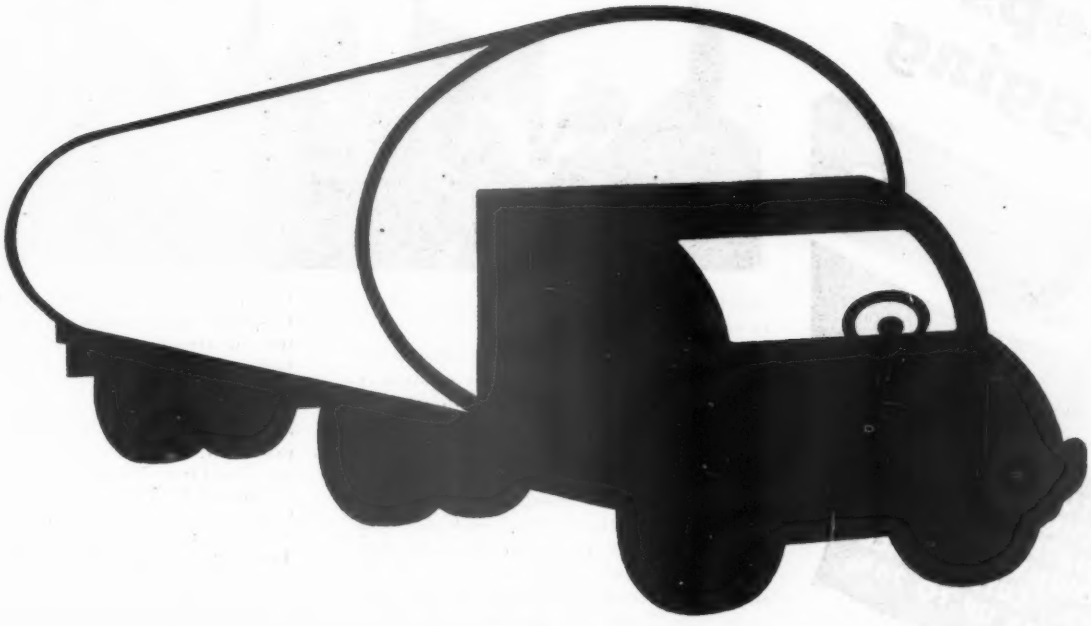
In support of this contention Webber offered the fact that the long range bombers required by the vast distances in the Pacific will require a fuel superior to the best we produce in large quantities today and the emphasis will be on higher quality. Materials likely to be then diverted from aviation gasoline are the less desirable base stocks and certain high cost ingredients that will no longer be absolutely needed. There is no thought of curtailing the operation of alkylation or isomerization plants. Isopentane will be used to the fullest extent and the only possible diversion of natural gasoline from its present use in high octane fuel will be in instances where it is going into the fuel as base stock and that particular base stock is inferior.

▸ **Pressure maintenance.** Stating that a discussion of pressure maintenance is somewhat removed from ordinary natural gasoline operations, Webber pointed out that many operate plants in connection with pressure maintenance compressors. He cited the fact that since the formation of the Office of Petroleum Coordinator (now PAW) quite a number of such plants have been constructed or are now being built. It is his opinion that the fuel benefits of pressure maintenance have been overlooked in the tremendous activity resulting from the industry's vigorous program for producing high octane gasoline. Applications filed for pressure maintenance plants at this time, however, indicate on a conservative basis, the ultimate additional recovery of more than 170,000,000 bbl. of crude. He said that these plants represent more than 50,000 hp. in compressor capacity and, including the natural gasoline recovery equipment, will cost about $16,000,000, which means that the cost of recovery of 170,000,000 additional bbl. of crude will thus be less than 10 cents per bbl. Webber strongly urged the industry not to overlook this fact in its postwar program.

▸ **Liquefied petroleum gas.** As far as liquefied petroleum gas is concerned, Webber said that winter fuel demands will take all available supplies including that production from new plants now under construction. The shortage of tank cars for transportation of liquefied petroleum gases still exists and the

F. D. Parker, *Bechtel-McCone Corp.* — R. C. Lassiat, *Catalytic Development Corp.* — Charles E. Webber, *PAW* — Dr. C. L. Thomas, *Universal Oil Products Co.* — E. P. Valby, *Richfield Oil Corp.* — W. M. Schaufelberger, *California Research Corp.* — G. M. Liljenstein, *California Research Corp.*

There is always a better way



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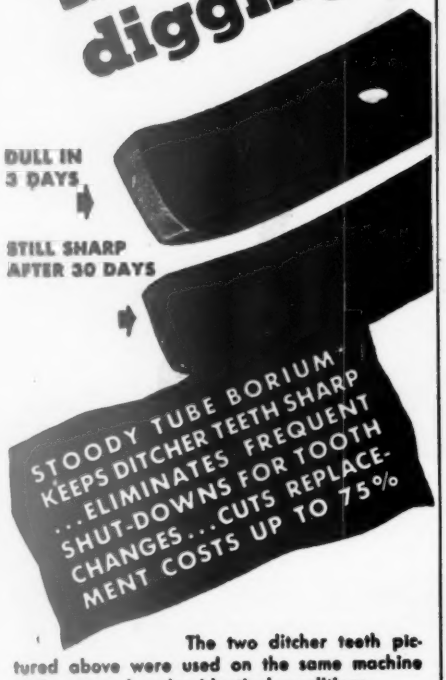
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Officers of the California Natural Gasoline Association and the committee on arrangements for the annual fall meeting October, 1944. Left to right: George L. Tyler, secretary; C. D. Gard, Union Oil Company, president; M. L. Arnold, Richfield Oil Corporation, vice-president; H. A. Dresser, The Fluor Corporation, Ltd., registration; H. P. Saueressig, Southern California Gas Company, general meeting chairman; R. R. Crippen, Texas Company, house committee.

shortage of the fuel will be more acute in some areas.

▸ **Postwar conditions.** Webber discussed the natural gasoline industry's postwar position by stating that, nationally, as the war with Japan draws to a close, the industry will be faced with a real problem in that markets for a production of 300,000 bbl. daily must be found.

Speaking of the position of California natural gasoline producers he said that the problem here will not be so acute since production, as a result of the war, is up only 27 per cent and this will readily be absorbed while, in fact, reduced crude production and the corresponding reduction in gas volumes will automatically curtail California production. California's problem, in his opinion, therefore is continuation of sufficient productive capacity to meet demands. He pointed out that while catalytic cracking in refineries will produce increased volumes of light products in competition with the natural gasoline plant, and that this will be serious in some parts of the country, it is his opinion that this will not be so serious in California.

From a national viewpoint, Webber stated that, in the postwar era, the natural gasoline plant operator can find the solution to the problem through production of motor gasoline and by developing outlets in the chemical, plastic, and other industries. This viewpoint was cited with especial reference to ethane-propane mixtures and he stated that chemical industry research and pilot plant work with these had begun over a year ago. During the last month his office has approved three projects calling for the installation of fractionating columns in cycling plants for producing ethane-propane mixtures to supply major chemical plants making acetaldehyde, alcohol, glycols, hexamine, carbon tetrachloride, perchlorethylene, chloroform, butadiene, and a host of other products.

During the same period he stated that at least four major chemical and plastic manufacturers made inquiry of PAW concerning further sources of propane and ethane mixtures. These, he contends, are the products the chemical industry is seeking. He pointed out that although these inquiries concerned the Gulf Coast area, there is no reason why California operators cannot become a part of the movement. To do this it will be necessary for the California operator to install or alter existing equipment required to produce ethane-propane mixtures in sufficient quantities to attract the chemical industry.

Webber closed his address on an optimistic note by stating that the war has brought the natural gasoline producer, the refiner, and the chemical industry closer together than ever before and that each has a greater appreciation of the value of the others' products. As a result, Webber believes that the situation will not revert to the conditions of 1940 when natural gasoline was a drug on the market.

▸ **Refinery men attend.** As if in evidence of Webber's closing remarks about the growing together of natural gasoline and refinery interests, one of the notable things of the C.N.G.A. was the excellent representation of refinery men. The program further bore this out as several of the papers presented were of definite interest to refinery men.

At the morning session, N. Van Wingen and E. P. Valby, Richfield Oil Corporation, presented a paper titled "Control and Detection of Reservoir Gas Movement in Pressure Control Operations." This was followed by "A Rapid Test for Isobutane (+) Fractions in Natural Gasoline Plant Absorber Residue Gases" jointly authored by W. M. Schaufelberger and G. M. Liljenstein, California Research Corporation.

At the afternoon session, following Webber's address, R. C. Lassiat, Catalytic Development Corporation, and F. D. Parker, Bechtel-McCone Corporation, presented a paper titled "Butane Dehydrogenation by the Houdry Process" and Dr. Charles L. Thomas, Universal Oil Products Company, presented a paper authored by Dr. H. H. Wenzke of that company titled "Some Catalytic Processes Utilizing Light Paraffinic Hydrocarbons." ★★★

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COMPLETE SOLUTION FOR SALT WATER PROBLEM IN TEXAS*

By A. M. BRENNEKE†

You should not be misled into believing this paper will present a truly complete solution for this problem. This is too much to expect, even though the subject is "A Complete Solution . . ." The problem is more far-reaching in scope than most people realize. Salt water can ruin and has damaged many sources of fresh water. It can retard industrial development. It can damage large areas where irrigation is of prime importance to the economy of the state and its citizens. It can, and has, ruined municipal water supplies. It kills fresh water fish.

You gentlemen who are daily concerned with water supply are no doubt aware that many water supplies are at least potentially endangered by the intrusion of salt water. Samples taken from the major rivers of the state at many points and over a period of years show that every major river in Texas is contaminated with salt water to some extent throughout one or more sections of its length.

The analyses also show that on some streams the concentration has been increasing, while on others, notably the Sabine and the Neches, the concentration has been decreasing after having risen to alarming proportions.

Every major river system in Texas has many oil fields on its watershed. These are the sources of most of the salt water in the streams. They are not the sources of all of it, as certain areas in West Texas, Oklahoma, and New Mexico are known to have surface soils that contain chlorides and sulphates. The contamination from these sources is natural contamination and it is extremely doubtful that any way can be found to prevent rainfall from bringing these chlorides and sulphates into the streams in solution.

However, when salt water finds its way from oil fields into the streams and underground fresh waters, the contamination is man-made and, because it has been caused by man, it can be prevented.

The study of this condition which the writer has been making for the last 4 months has developed the following facts that are of concern and should be of interest to all citizens of Texas.

Prior to any control of salt water from the East Texas oil field the municipal water supply of the City of Beaumont was critically contaminated by this salt water.

In 1936 the City of Longview was forced to expend over $400,000 to procure a new surface supply due to the contamination on the Sabine River by oil field salt water. Subsequently, oil was found and is now being produced in three separate areas on the new watershed, and one of these areas is producing considerable salt water. Fortunately, the producers are now controlling it and, so far as is known, none is being released where it can find its way into the supply.

*Presented at Southwest Section of the American Water Works Association meeting, Austin, Texas, October 19, 1944.

†Engineer, Salt Water Control, Texas State Department of Health.

Seriousness of contamination to fresh water is discussed and some suggestions are made for correction of this injurious condition.

Will the City of Longview be forced again to expend several hundred thousand dollars for a third water supply?

For many years the City of Graham used Salt Creek, a tributary of the Brazos as their water supply. In spite of its name, the water was fresh and good at the plant intake. In 1929 Graham was forced to abandon this supply because of oil field salt water contamination. A new supply was procured upstream on a tributary that had adequate runoff and was in an area with no oil development. There are now about 130 oil wells on the new watershed, most of which are producing salt water. A few wells are just on the watershed at the head of the reservoir and salt water from these is supposed to be ditched through the divide away from the watershed. The only other known attempt to control salt water is by placing it in surface pits, where evaporation removes some of the water, but none of the salt. What is retained is released during periods of good flow in the streams. In practice this method has not proved satisfactory and is most undependable. As a result, the chloride content of Graham's reservoir has risen from zero ppm. when new, to about 38 ppm. this summer. This is not yet serious, but will it be? Will the City of Graham be forced again to expend a large sum of the taxpayers' money, for a third water supply?

A few years ago the water supply for the City of Lockhart was a shallow stratum of underground water south of the city. On the upper reaches an oil field was developed and after the production of salt water started, pits were dug for the storage of the salt water. These pits penetrated the water bearing gravel bed and caused rapid and direct contamination of the supply.

Practically nothing is now known of the degree of infiltration or the intrusion of salt water into the lower water-bearing sands. The time for infiltration at the surface to reach a well some miles away is probably years, possibly many years. It therefore follows that a high salt water intrusion would require years to become noticeable, and just as many years to be cleared up.

Numerous reports have been received of the salt water contamination of shallow wells in and near oil fields. This is a condition that still exists in many oil fields and it is not considered necessary to cite specific cases here.

So much for water supply. In the use of water for irrigation the Rio Grande Valley, the Pecos Valley and the Gulf Coast area east of Houston, are probably the most important to the state. The rice growers around Beaumont and Orange were and still are, concerned about the chloride content of the water they use for irrigation. At present, chlorides are low enough for satisfactory use in the lower reaches of both the Sabine and the Neches. This is due to the control of the salt water from the East Texas oil field, however imperfect this control is known to be, plus dilution from the tributaries below the oil field.

On the Rio Grande, samples taken this year showed chlorides as high as 800 ppm. This is too close to the limit of tolerance reported for many crops grown in this area and is too high for satisfactory municipal use.

On the Pecos, near Girvin, chloride contents ranging from 3000 to 5050 ppm. were found in the 108 samples taken between April and August, 1943. The Pecos is one of the rivers that carries considerable natural contamination, but it also carries drainage from oil fields. Samples taken from small creeks below oil fields showed chlorides present varying between 25,000 and 46,000 ppm. These were on the Pecos wastershed, and add to the natural contamination.

We hear much these days about the industrial development of the state; about large firms erecting huge plants for processing some of the resources of the state, either agricultural or mineral; about the reconversion of existing war facilities to peace-time pursuits. The quantity of water any such large industrial plant needs does not seem to have entered our minds. To illustrate, the Southland Paper Mills near Lufkin, report they use 10.0 mgd. and then reuse 1.5 mgd. of this. It is also reported that the Dow Chemical Company's plants near Freeport, anticipate a water requirement of 100 mgd. In addition to the huge quantities needed, there are minimum standards of quality that must be met for the successful operation of an industrial plant, and almost without exception the chloride content must be much lower than for a municipal supply.

The Game, Fish and Oyster Commis-

sion has been most active in efforts to control the chloride content of the streams within safe limits for fresh water fish. The term "safe limits" varies for several species of fish common to our streams and more experimental work is needed to determine the proper limits. What work has been done indicates that chlorides to the extent of about 2000 ppm. are probably too high for some fresh water fish in Texas, but are not too high for others.

Briefly, the foregoing are the conditions that do exist. You have heard of the controls that are being practiced in the East Texas oil field. Admittedly, they are not too good and depend largely on the individual producer.

What is the solution to the problem? Only three possibilities appear to have any merit. These are: (1) Keep the salt water out; (2) dilute it with fresh water; (3) use a combination of these.

Existing state law prohibits contaminating a water course to a degree detrimental to any of the normal uses of the stream or its waters. State enforcement agencies have set 2000 ppm. as the chloride limit below the East Texas oil field, taking into consideration the present needs of the waters in the Angelina and Neches rivers and the diluting flow from tributaries. This is all right so long as no use is made of the stream that will require a higher quality, for such distance downstream from the point of contamination as may be needed to permit the entrance of sufficient dilution water to lower the chloride content to the desired point. In some rare cases this may be but a few miles. In others it will likely be around 100 miles, as the Sabine at Logansport is not very satisfactory for municipal use, many miles below the point of contamination. In still other cases a stream may be ruined for nearly its entire length, particularly if a chloride content below 35 or 40 ppm. is required.

The law also provides a penalty for violation—a fine of not less than $100 nor more than $200, and permits the issuance of an injunction to prevent a recurrence of the offense. The fine does not seem to have been effective in stopping the dumping of salt water. It appears to have worked on the order of fining a theater operator $20 for opening on Sunday. The fine was paid, but the theater continued to open on Sunday. The operator merely made $20 less that day than he would have made otherwise.

Court proceedings through injunction are a real threat to an oil producer who violates the law, but it is such a slow, cumbersome process that many who are familiar with conditions, including jurists, are of the opinion that revision of the existing law is needed, particularly as to its enforcement. It appears to the writer much more desirable to prevent contamination than to try to correct it after it has happened.

To this end, the following suggestions are offered as one way to control salt water in Texas:

1. By statute, create a Salt Water Control Commission, composed of the state health officer, the chairman of the board of water engineers and the chairman of the Game, Fish and Oyster Commission. This commission should be instructed to employ a qualified registered professional engineer as executive, together with an adequate staff to gather data, to care for the operation of the office, and to prepare cases against violators of the law.

2. By statute, instruct the Railroad Commission to shut down any well in any oil producing area within five days of the receipt of a certificate from the Salt Water Control Commission that salt water from any certain well or group of wells is being permitted to enter a water course or a fresh water bearing stratum of underground water, to an extent that is detrimental. Such well or group of wells to remain closed down until the Salt Water Control Commission has certified to the Railroad Commission that the producer has made arrangements for the disposal of salt water that are satisfactory to the Salt Water Control Commission. Instruct the Railroad Commission that no oil from such well or wells so shut down is to be accepted in commerce during the period of the shutdown. Require the issuance of a drilling permit by the Railroad Commission prior to the drilling of any well for oil or gas, and require that such permit shall not be issued until the receipt of a certificate by the Salt Water Control Commission that the operator has filed plans for the control and disposal of all oil well wastes and that such plans have been approved by the Salt Water Control Commission.

3. Authorize the Salt Water Control Commission to prescribe such regulations as may be deemed necessary for the enforcement of the law, and to require the submission and prior approval of all proposed methods of salt water disposal contemplated by all producers. Require that no well shall be drilled for oil without first obtaining a drilling permit as stated in paragraph 2 above, and fix a heavy penalty for violation of this requirement.

4. Assess a charge of 1 cent per 100 bbl. of oil produced against each producer, to be paid by the first purchaser of oil from the well and paid monthly to the state instead of to the producer. This fund to be for the exclusive use of the Salt Water Control Commission in salt water control and enforcement.

5. Repeal all conflicting sections of the existing law. The cost of operating such an agency is estimated to be about $75,000 the first year and about $70,000 per year thereafter. One cent per 100 bbl. of oil produced is adequate. The State of Kansas charges 4 cents per 100 bbl. of oil for supervision of salt water disposal.

It is realized this is but one of several ways to finance the proposed commission. Financing could be by legislative appropriation, but it is not believed the cost should be borne by the taxpayer, but by the oil producers. It is believed that an assessed charge should properly be against the production of salt water on the basis of quantity produced, rather than against the quantity of oil produced. However, simplification seems to indicate the proposed method is easiest and cheapest, and it is of minor significance to a producer whether the assessment be against oil produced or against salt water produced.

It should be noted that all the so called major companies and a great number of smaller producers are fully cognizant of conditions and are sparing no effort to keep salt water contamination of fresh waters within safe limits.

It is believed these proposed changes in the present law will permit a more rapid correction of violation of the law, create a fuller understanding of the responsibilities of the producers and of the several state agencies now concerned, result in a greatly improved condition in many of the streams of the state, and at the same time work no hardship on any oil producer who is trying to protect the fresh waters of the state.

The foregoing is one workable solution. Another with some merit would be to devise some system whereby it would be to the advantage of each oil producer to care properly for his salt water. Human nature being as it is, a solution along these lines appears doubtful at least. Even if satisfactory in principal, some control would be necessary to determine what constitutes satisfactory disposal. Experience for many years has shown this cannot be left to the individual producer. Quite possibly the best solution would be a combination of these two methods, that is, close supervision with a charge for the cost of supervision and a credit for good control, possibly in the way of some additional allowable oil production to offset the cost of supervision.

From the foregoing it is hoped you will realize something of the magnitude of the salt water problem in many sections of the state. Much remains to be done in the study being made before the completed report can be filed. Your assistance is requested, by bringing to the writer's attention any conditions bearing on the subject of which you have knowledge and by any comments, criticisms or suggestions you care to make that may be helpful, so that the proposed report may truly present "A Complete Solution for the Salt Water Problem in Texas."

★ ★ ★

Pressure drops

Bottom hole pressure in the East Texas oil field dropped 6.27 lb. per sq. in. during September to total 1,001.61 lb. October 1. The decline is expected to bring requests for smaller production in the field, which has been drawn upon heavily to supply the Big Inch pipe line to the East. It now has an average allowable of 378,140 bbl. daily. A total of 352,923 bbl. of salt water was returned to the Woodbine reservoir, 81.19 per cent of total, in an effort to maintain pressure.

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CARE AND MAINTENANCE OF COOLING TOWERS

By **HAROLD A. DRESSER,** The Fluor Corporation, Ltd.

EXCLUSIVE MANY companies have set up definite inspection and maintenance schedules for all equipment except cooling towers without realizing that a decrease in cooling tower efficiency, due to lack of maintenance may affect seriously the efficiency of the entire plant.

If inspection and maintenance schedules for cooling towers have not been set up in the past, such schedules should be introduced as soon as possible. From experience gained in the inspection and repair of several hundred cooling towers of all makes, it was found that a scheduled inspection of cooling towers at definite periods should cover the following:

1. *Cooling tower basin*
2. *Cooling tower anchorage*
3. *Tower framework*
4. *Decking*
5. *Distribution systems*
6. *Cooling sections or coils*
7. *Mechanical equipment*

▼ **Cooling tower basins.** Basins for collecting cooling water are usually constructed of four materials: Concrete, steel, redwood, and leadlined redwood or steel. The material to be used should be governed by the actual location of installation—that is, whether it is at ground level, on a roof or a substructure—and also by the effect of the water to be circulated and collected on the material of which the basin is to be constructed. Before selecting the material for a collecting basin, the water should be analyzed and its effect on the deterioration or decomposition of the basin material studied in detail. A few extra dollars spent in proper consideration of the cooling tower basin material initially are insignificant in comparison to the amount necessary to rebuild a basin at some later date, and the amount of revenue lost in the plant shutdown necessary for such rebuilding.

Experience has shown that many concrete basins have failed due to the action of the circulated water on the concrete. The life of concrete basins can be greatly lengthened by using special cements that are resistant to the action of chemicals in water or by covering the surface of the concrete with a protective coating of asphaltic base material. Both methods have been successful and it is recommended that one or the other be considered by all users of cooling towers.

Steel basins should be protected against corrosion by covering the surface with a prime coat of red lead or similar material, followed by several coats of an asphaltic base paint. Redwood basins can be protected from deterioration by impregnating the wood with one of several water repellent chemicals. This type of basin can also be impregnated with oil, but this method of protecting the redwood presents a fire hazard in addition to making it possible for the cooling water to be contaminated with oil, thereby reducing cooling efficiency of the tower.

If either redwood or steel basins must be used and a great degree of permanency is required, the basins should be leadlined. Whenever steel or redwood basins are installed on the ground, a sub-foundation of concrete or crushed rock should be installed to provide adequate drainage. This prevents rapid corrosion of the steel basin and dry rot in the redwood basin. All types of basins should be inspected at regular intervals, and when necessary should be drained, washed down, and cleaned.

Hotwells, suction pits, settling ponds, and any other means of collecting water flowing into or from the basin should be periodically inspected and cleaned to prevent excessive accumulation of debris. In order to keep the water as clean as possible, it is recommended that suction pits be fitted with screens. These screens should be installed in pairs so they can be cleaned one at a time without shutting the plant down.

Definite inspection and maintenance schedule advised as essential to efficiency of tower, which affects efficiency of the entire plant.

▼ **Cooling tower anchorage.** Inspection of cooling towers in service for several years has shown approximately 50 per cent of the anchor bolts to be ineffective due to the corrosive action of the water. Of the ineffective bolts, some were completely corroded through, and the cross-sectional area of others reduced from 50 to 75 per cent. Although defective anchorage conditions existed in many cases, the dead weight of the tower in operation was adequate to prevent overturning at normal wind velocities. Had these towers been dry, chances are they would have overturned with wind velocities slightly above normal for these areas.

Because of its lower height and greater width the mechanical draft tower, compared to the atmospheric type, is less likely to be damaged by wind if the anchorage becomes defective. It is well that the mechanical draft tower has greater stability, however, because it usually receives insufficient care in the maintenance of those anchor bolts and castings on columns inside the structure.

Anchor bolts can be protected from the reaction of the water by covering them with an asphaltic base paint or with putty. Both are fairly effective and at the same time practical and economical.

▼ **Tower framework.** An extensive study of several hundred cooling towers has revealed that cooling tower lumber is subject to decomposition in contact with certain types of water. This decomposition reveals itself by the apparent rotting of the lumber. These waters seemingly extract the lignin and cellulose products, leaving the wood in long stringy fibers and rendering the entire mass so porous that it is impossible to hold nails or other hardware in the lumber. This phenomenon has been called delignification.

Delignification is caused by the water being either too alkaline or too acidic, although excessive alkalinity appears to be by far the more destructive. Decomposition is caused directly by sodium carbonate combining with the lignins, tannins, and cellulose ingredients of the lumber.

Inasmuch as continuous use of excessive acid waters would corrode both piping and condensing equipment, such conditions are seldom allowed to exist for long. On the other hand, the sodium carbonate does no damage to cooling tower hardware with the exception of certain zinc alloys, and consequently alkaline conditions have been allowed to exist. Sodium bicarbonate of itself has little effect in the causation of delignification, and this is true also of other salts; however, sodium bicarbonate deposited in alternately wet and dry locations tends to form sodium carbonate. As sodium bicarbonate can concentrate on wet and dry areas and form normal sodium carbonate, it is apparent that any sodium bicarbonate in the circulating water may be injurious and therefore should not be ignored in water analysis. Manifestly, the higher the concentration of sodium bicarbonate, the greater will be the tendency to concentrate at such areas and produce normal sodium carbonate. It might be stated, therefore, that the certain way of preventing de-

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	HOUDRY Fixed-Bed Units	T. C. C. Moving-Bed Units
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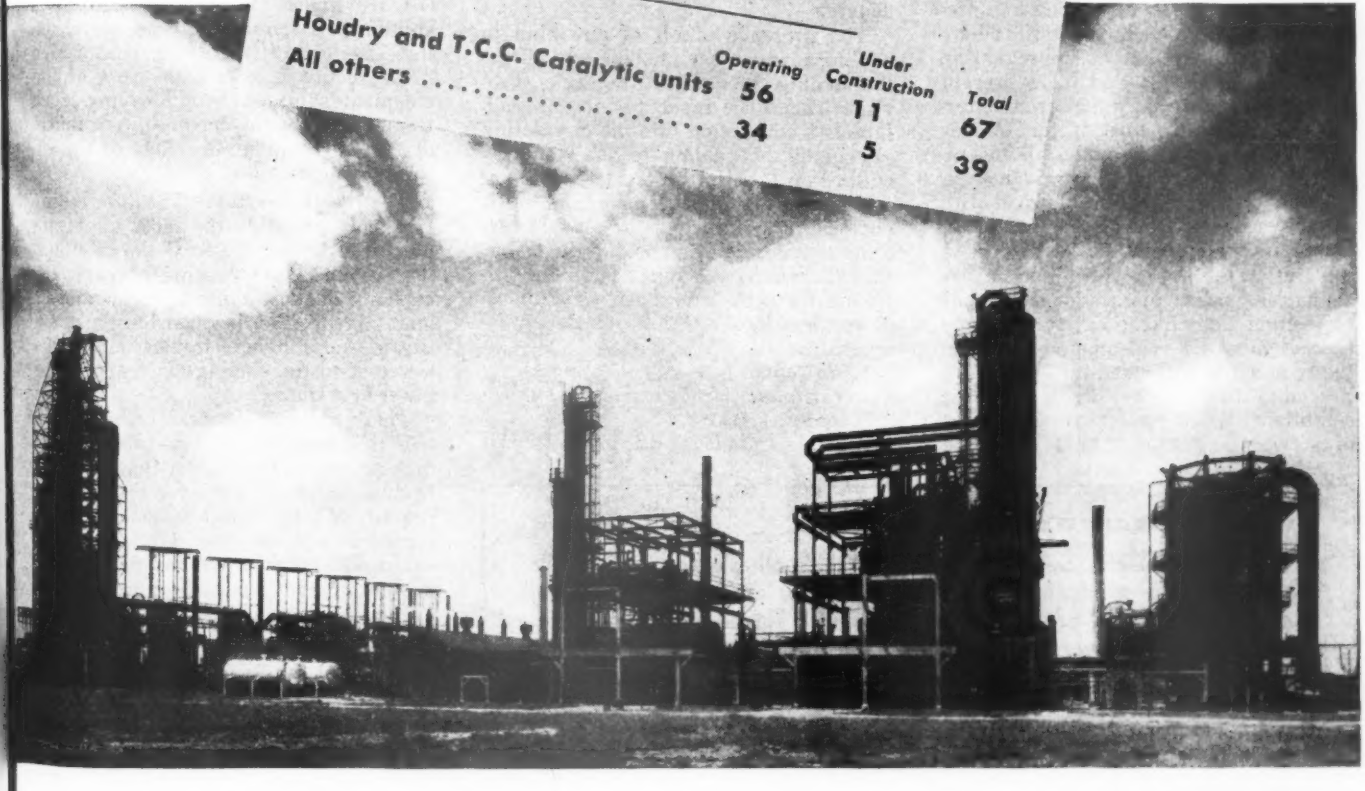
Continental Oil Company		3
Crown Central Petroleum Corporation		2
General Petroleum Corp. of California		4
Gulf Oil Corporation	1	3
Magnolia Petroleum Company	4	2
Pure Oil Company		2
Richfield Oil Corporation		4
Sinclair Refining Company	2	1
Socony-Vacuum Oil Company, Inc.	7	2
Southport Petroleum Company	1	2*
Standard Oil Company of California	1	1*
Standard Oil Company (Ohio)	2	4
Sun Oil Company	6	
Tide Water Associated Oil Company	1	
Union Oil Company of California		
U.S.S.R.	8*	

* Under construction

	Operating	Under Construction	Total
Houdry and T.C.C. Catalytic units	56	11	67
All others	34	5	39

Below: T. C. C. unit (left) and Houdry fixed-bed unit (right center) at Sinclair's Houston refinery.



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lignification is to eliminate all sodium bicarbonate or sodium carbonate from the circulating water. At the same time, however, water must not be produced of such low pH value that it will be corrosive to any of the metals used in this equipment.

Evidence of delignification in the tower framework can be found most easily in the top members directly above the distributing system. This takes the form of white salts on top of or in posts, braces, and transchords. Where decomposition is internal, the exterior of the wood is spongy to the touch and can be dented with ease to a depth of ½ in. or more.

No adequate cure for delignification has yet been found but many things are being done to minimize the delignifying effect of water on cooling tower lumber. Thorough impregnation of the lumber with oil seemingly prevents sodium carbonate from penetrating the lumber, thereby reducing delignification. Impregnation with oil, however, presents a fire hazard in addition to making it possible for the water to become contaminated with oil, thereby reducing cooling efficiency. This method, therefore, cannot be recommended as a method of preventing delignification.

Several years ago, we installed some towers in which all the lumber was thoroughly treated with special water repellent chemicals. This treatment was given after the lumber was cut to detail, all holes drilled, and all nailing and prefabrication completed. The object here was the same as that of impregnating the lumber with oil; that is, to prevent salts from the cooling water from entering the grain structure of the lumber itself. The use of this method is too recent to provide conclusive evidence on whether the impregnation of wood with water resistant chemicals has helped in combating delignification.

Painting the tower with aluminum or asphaltum paints unquestionably tends to prevent delignification. At the same time it must be remembered that virtually no paint will stand up for any appreciable time under highly alkaline conditions. When a cooling tower is out of service long enough that it can be thoroughly dried and repainted once a year, and when the economics of that painting are favorable, delignification may be prevented by that means.

To date the only seemingly safe method of preventing delignification is the complete, or virtually complete, elimination of sodium bicarbonate and sodium carbonate from the circulating water.

Where delignification is serious, the framework, as well as any other affected parts, should be immediately replaced and steps taken to eliminate or minimize the causes for such decomposition.

▼ **Decking.** Decks and grids are of many designs and constructions. Their purpose in a cooling tower is to maintain proper distribution of the water down through the tower and to provide maximum contact with the cooling air. It is necessary, therefore, that decks be kept clean and in proper position at all times. The efficiency of decks is affected by damaged or sagging members and by the presence of algae, salt deposits, oil, dirt, and pieces of wood or steel. Those towers using flat horizontal decking are more apt to collect foreign matter than those using a bowed or vertical deck. Some towers inspected have contained so much dirt and algae in the top decking that small trees three or four feet high have been seen growing in them. This, of course, is an extreme condition; but it illustrates that some operators are not fully aware of the conditions resulting from inadequate maintenance procedure.

The presence of oil of any kind in cooling tower water immediately affects the cooling efficiency of the decks. Provision should be made to prevent such liquids from getting into the circulating system of the cooling tower. Not only will oil on the decks, outside sheathing, and framework affect the cooling, but it decreases the ability of the outside covering to hold the water within the tower, thus increasing the water loss. The following methods have been used to remove these liquids:

a. Steam
b. Solvents
c. Complete replacement of the decks.

Algae is a plant growth present in all water. Its growth varies in accordance with the temperature of the water being circulated over the tower—the hotter the water, the more rapid the growth. For this reason, the growth of algae is generally more noticeable at the top of the tower than it is at the bottom. On many towers inspected, the top deck was entirely covered with algae. This resulted in the water being distributed down the extreme outside of the decks, rather than through them and being forced to channel all the way to the basin. Cooling obtained in these cases was only a fraction of what was to be expected.

There is no sure remedy for the complete elimination of algae in cooling water. Numerous chemicals such as chlorine, potassium permanganate, copper sulphate, and others can be added to the water to kill this growth; the chemical used must be changed from time to time, however, as algae has the property of becoming immune to certain chemicals. In adding such chemicals to combat the growth of algae, care should be taken to analyze properly the effects of the chemical on cooling water. In some cases of this nature the reaction resulting from addition of such a chemical to cooling water caused such a heavy precipitation that the entire tower decking was coated with lime more than half an inch thick. In some cases these deposits have been removed with hammers, and in others required complete replacement of all decking.

Once algae has gained headway a shutdown is required for proper cleaning. This can often be done with a high pressure fire hose or some very strong chemical solution. In all events, such treatments should be followed immediately by complete drainage of the entire cooling water system.

▼ **Distribution systems.** The distributing system is probably the most important part of a cooling tower. If the distributing system is not working properly the capacity of the cooling tower cannot be maintained, either in regard to the quantity of water being circulated over the tower or to the cooling efficiency of the tower as a whole.

There are two general types of distributing systems, i.e., low pressure and high pressure. The former type operates from atmospheric pressure to 2 or 3 lb. per sq. in.; the latter is generally designed to operate from 4 to 30 lb. per sq. in. The efficiency of any distributing system depends upon three conditions:

a. Quantity of water circulated
b. Operating pressure at nozzles
c. Freedom from foreign substances

Item *a* needs no discussion here. Items *b* and *c*, however, have caused trouble in maintaining cooling tower efficiency. The average operator does not seem to appreciate the effect that particles entrained in the cooling water can have on distributing systems. In some towers inspected nozzles are found completely plugged by accumulation of scale, dirt, and other matter. In others, especially the high pressure nozzles, these particles have so worn the nozzle orifice that its effective opening is much larger than

Swedish plants up production

Operated by the Swedish Navy, the shale-oil plant at Kinnekulle, Sweden, is now producing 70,000 bbl. of crude shale oil annually with plans laid to expand production to 91,000 bbl. The second commercial-size plant, built at Kvarntorp in Narke some two years before the beginning of the war, now has a potential annual capacity of 259,000 bbl. of crude oil annually. The latter plant was originally constructed with facilities for retorting by the Berge method, which uses a large number of retorts, the Rodkesholm method, with special devices for production of ammonium sulphate, and the tunnel kiln method.

A fourth system is being tested at Kvarntorp and accounts for slightly more than a fifth of current production by volume. Worked out by a leading technologist, the principle governing the method is based on heating of the shale body by vertically placed electric resistance heaters by means of which the "oil gases" are driven horizontally along the share strata toward a central drill hole, which collects the gases and draws them off. If proved economical, the system offers many advantages.

Photographs courtesy Texas Iron Works.

HYCAR does the job where others fail!

HERE'S one example. A southwestern operator was having trouble maintaining an efficient pack-off between tubing and oil string. When he removed the packer from the well he found that the so-called oil-resistant packer rings had completely disintegrated. Then Hycar was specified—and that was the end of trouble.

Superb performance of this oil resistant rubber is the reason why Hycar was selected for use in Texas Iron Works' JSA Hook Wall Control Head Packer shown in the illustration. Those six packer rings will stay resilient and resistant to oil and gas regardless of how many times the packer needs to be set, unset and reset during the life of the well. Nor will they ever stick to the casing wall, or swell and bind in place.

But oil resistance is only one of Hycar's many unusual properties. Look at the list in the box to the right. It almost seems that Hycar was specially developed for oil field applications. Gate packers in mud line valves, casing head seals, gaskets and seals of all kinds, drilling and suction hose—these are just a few of Hycar's many oil industry uses.

Next time ask for parts made of Hycar. Test them yourself in your own applications. Learn for yourself that Hycar can help reduce operating costs—that it's wise to use Hycar when the going gets tough. *The Hycar Chemical Co., Akron 8, Ohio.*

WHAT HYCAR DOES IN OIL FIELD APPLICATIONS

1. Resists oil and gas—even under high pressure.
2. Resists action of abrasive-laden fluid under high pressure and at high velocity.
3. Wears at slow rate even under worst conditions.
4. Makes a positive, leak-proof seal, even after a long period of service.
5. Provides high elasticity.
6. Gives high tensile strength.
7. Has minimum tendency to cold flow and compression set.

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required for quantity of water handled. Result is the loss of pressure head so necessary to proper breakup of the water. Those distributing systems constructed with troughs or launders have been found completely filled with algae, scale, and dirt. It should be remembered that the fastest rate of cooling in any tower takes place in the initial flash of water from the nozzle. Anything that will prevent full and adequate distribution on the first deck will affect final water temperatures far more than any obstruction in the lower parts of the tower. Because the distributing system is the most critical cooling point in the tower, it should receive a thorough inspection and cleaning at least once a week.

▼ **Cooling sections or coils.** The foregoing discussions of scale formation and water quality should be applied to the maintenance of cooling sections. Aside from obvious losses in heat transfer rates, scale formation on the outside of these coils can very often hide a badly corroded part or even a slight leak, which introduces oil or some other impurity into the circulating water. Where scale formation is bad, coil sections should be cleaned as often as is necessary to maintain adequate heat transfer rates. Complete instructions for the care and maintenance of cooling sections should be obtained from the various manufacturers of this equipment and their recommendations followed faithfully to assure maximum life and fullest capacity.

▼ **Mechanical equipment.** The problem of maintaining mechanical equipment in the atmospheric type tower is, of course, limited only to the pump and driver necessary to circulate the cooling water. In those instances where the cooling tower and cooling water pump house have been placed at a distance from the main part of the plant the cooling tower, pumps, and drivers have had insufficient maintenance and are sometimes in a poor state of repair. More attention seems to have been paid to the mechanical draft type of tower because of the greater amount of mechanical equipment used. It should be pointed out that the mechanical draft type tower will require, far more than the atmospheric type, a very strict schedule of inspection and maintenance. All gears, motors, flexible shafts, and fans require periodic inspections, cleaning, and service. The great majority of mechanical troubles encountered in this equipment can be eliminated through timely and effective service.

Generally speaking, lubricating oil in the gear reducer should be checked preferably each month, and no less frequently than every four months. Water has crept into the gear box in some cases and pushed the oil to another portion of the gear where it was no longer lubricating moving parts. As expected, the teeth of the gear were badly worn, pitted, and some had even broken. Seals on a gear should be inspected thoroughly every month to determine their effectiveness. In the induced-draft type of tower where the gear and fan are operating in a warm and very humid atmosphere, it is well to provide some means for regularly draining water that has crept into the gear box through breather pipes.

Flexible shafts connecting the gear with the driving mechanism should be inspected every two or three weeks and greased with a heavy oil. Most mechanical-draft cooling-tower fans are so constructed as to allow the escape of water that might be entrapped within a hollow fan blade or in the hub. It is well to check the fan at least once a month to ensure that no water is being trapped within the blade, as the additional weight of liquid not only throws the fan out of balance, but if allowed to continue may cause the fan blade to break or fly off, with consequent possible damage to other mechanical equipment or to the cooling tower itself. Small weep holes for the escape of this entrapped water should be kept open and, if necessary, increased in size.

The maintenance and care of motors, engines, and other types of driving mechanism are generally well covered by the various manufacturers of this equipment and therefore will not be discussed here.

An analysis of this discussion will show that it is virtually impossible to set up a standard schedule of inspection for all cooling tower users. Each operator must establish his own inspection schedule after making an analysis of the water to be circulated. It is recommended, however, that the time lapse between such scheduled inspections be kept to an absolute minimum. ★ ★ ★

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Describe the grade of oil or gas and firing rate, also fuel pressure.

Indicate the steam or air pressure available for atomizing.

Five furnace draft conditions.

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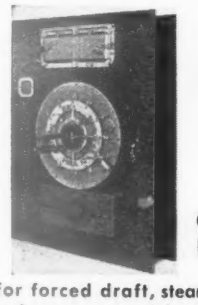

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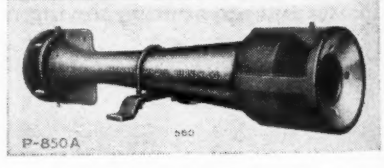

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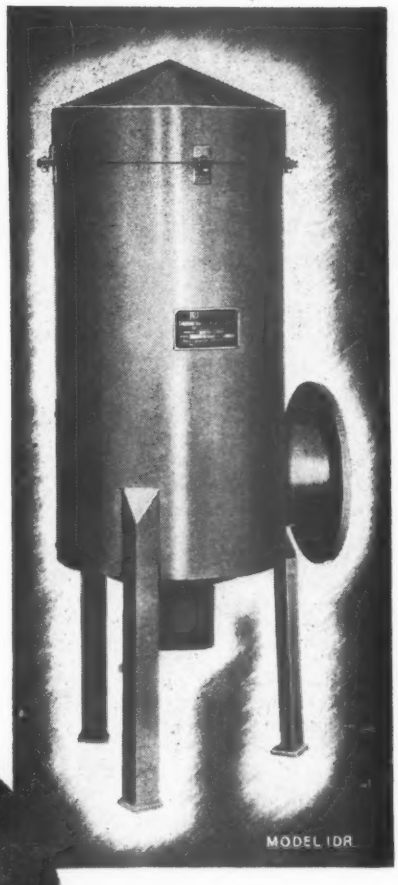

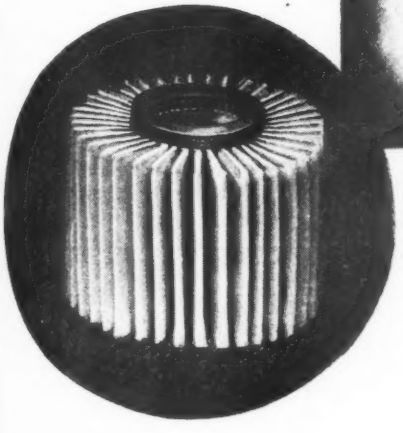

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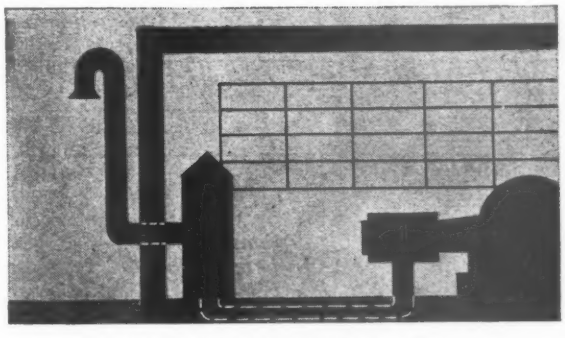
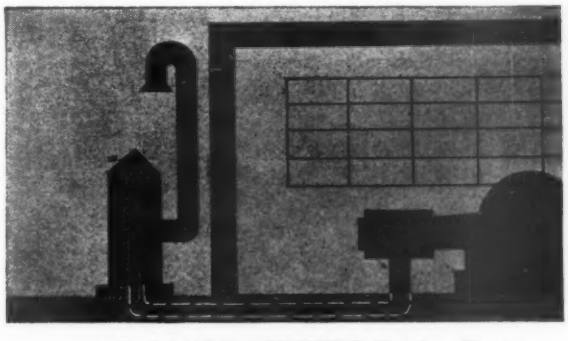


Model IDR INSIDE Engine Room



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HIGH SLIP ELECTRIC MOTORS USED FOR OIL WELL PUMPING

By **KENNETH N. MILLS,** *Texasteel Manufacturing Company, Works Manager*

EXCLUSIVE THE speed load characteristics of the prime-mover used on an oil well pumping unit is one phase of the oil well pumping problem that can have a great effect on the performance of the pumping system. Although this phase of the oil well pumping problem has been investigated by W. C. Dreyer of the Westinghouse Electric and Manufacturing Company, W. C. Layne, and others, it has not received the attention it deserves. Probably it has not received attention because it is not readily controlled in most prime-movers and on some actual tests to determine its effect the investigators have been expecting one result, which was not attained. In looking for this result, they have overlooked some of the other advantageous effects. This characteristic is readily controllable in the induction type electric motor.

Speed load characteristics of prime mover used on oil well pumping unit can have marked effect on performance of system.

In this type prime-mover, it is expressed as the per cent of slip at full load. The per cent slip expresses the amount the speed of the motor drops below the synchronous speed when it is carrying its full load. Normal slip motors have a full load slip of 2 to 3 per cent and high slip motors have a full load slip of 8 to 10 per cent at full load. The high slip type motor was originally developed for applications using heavy flywheels where it was desired to store energy in the flywheel during periods of minimum load and remove this energy from the flywheel during periods of peak load. The high slip motor accomplishes this result by shirking the load, i.e., slowing down during periods of maximum load and permitting the flywheel to give up some of its kinetic energy. The energy lost by the flywheel is restored by the motor during periods of low load. Some typical applications of this type motor are punch presses, shears, forging presses, etc. On applications of this type, its principal advantage is a material reduction in the peak power demand.

When the high slip motor is applied to conventional pumping units, it offers numerous advantages from both the electrical and mechanical viewpoints. From the electrical viewpoint its advantages are:

1. *Lower peak power demand.*
2. *Lower average power consumption.*
3. *Less motor heating due to lower r.m.s. current.*
4. *Less fluctuation in power demand on distribution system.*
5. *Easier starting due to high starting torque characteristics of high slip motor.*

From the mechanical viewpoint its advantages are:

1. *Lower peak load on pumping unit driving system "V" belts and speed reducers.*
2. *Reduced polished rod load (not found in all applications.)*

The results of a recent series of tests on a well whose dimensional characteristics are shown in Table I demonstrates a large number of these advantages.

In conducting this series of tests

TABLE 1

Depth to pump	2740 ft.
Rod size	⅝-in. dia.
Plunger size	1½-in. dia.
Pumping speed normal slip motor	16 SPM
Pumping speed high slip motor	16.5 SPM
Length of stroke	26 in.

TABLE 2

Motor type	Normal slip	High slip
Line voltage	484	492
Max. current, amp	12.7	6.4
Min. current, amp	10.3	3.8
Max. power factor, per cent	50.7	81.8
Min. power factor, per cent	31.5	76.0
Max. power input, kw	5.2	3.8
Min. power input, kw	2.0	2.0
Average power input, kw	3.6	3.1

FIG. 2

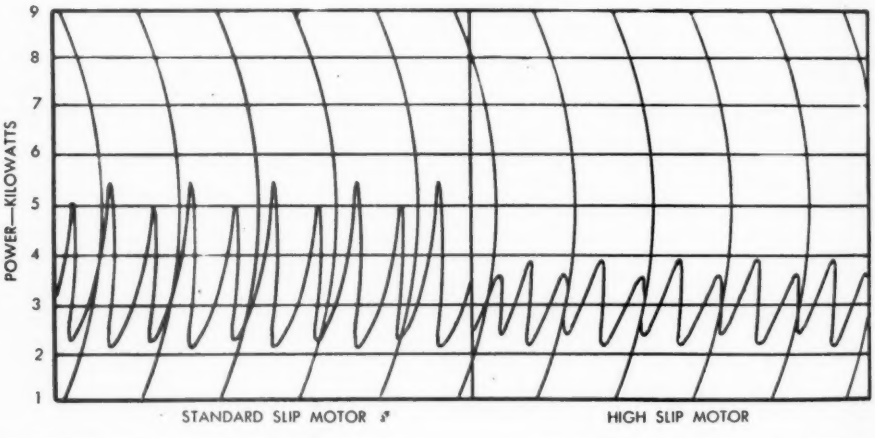
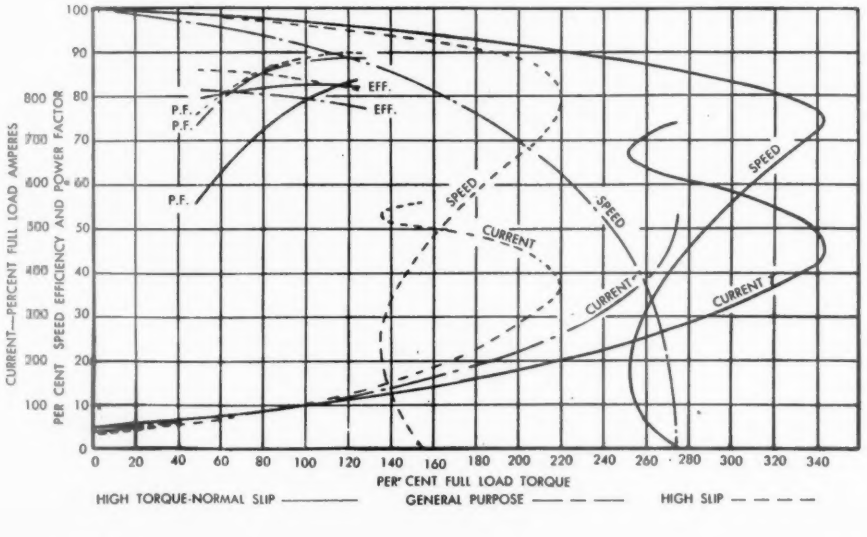
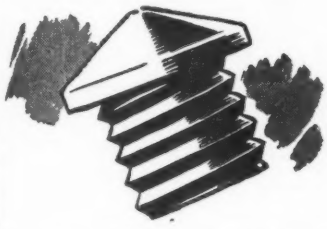


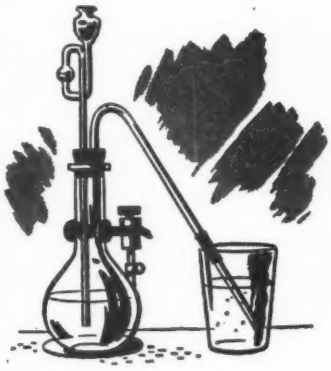
FIG. 1



Typical of the exhaustive field tests which marked the development of the modern, high speed Cummins Diesel, was the gruelling 14-day grind which came to an end on Christmas Day, 1932, at the Indianapolis Speedway. Here, under AAA supervision, a Cummins-powered Indiana truck set a non-stop distance record for trucks: 14,600 miles (5,840 laps of the 2½-mile oval!).



The injector cup wiper is an inconspicuous part of the Cummins Diesel, but its development made a conspicuous contribution to the Cummins Diesel's efficient and economical performance. This patented cup wiper, perfected only after countless modifications in piston design, eliminates carbon on the injector cup, creates additional turbulency, assures more complete combustion.



Metallurgy plays an important role in the Cummins Diesel trend to ever lighter, stronger construction. Example: 5,000 samples were analyzed in selecting the cast iron for the block—a foundry was rebuilt and its methods completely revised—but the increase in tensile strength from 20,000 to 50,000 pounds per square inch more than justified the cost.

CUMMINS DEPENDABLE DIESELS

Automotive Models: Designed for all types of heavy-duty trucks in either highway or off-the-highway service.

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Industrial Models: Portable and stationary engines, power units, and generating sets for service in any industry requiring heavy-duty power.

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Marine Models: Propulsion engines and marine type generating sets designed for all types of fishing boats, work boats, and pleasure craft.

Spade Work

The diesel's higher thermal efficiency was proved many years ago . . . but it took the builders of Cummins Diesels to prove that diesel engine weights and dimensions could be brought within practicable limits. They proved it in 1932 with the original high speed diesel . . . proved it after 14 years of intensive "spade work" in the refinement of lubrication, cooling, metallurgy and many other aspects of design and construction . . . proved it by putting diesels in equipment and on jobs where diesels had never worked before. Today, you will find diesels in virtually every automotive, industrial, and marine service that requires heavy-duty power . . . and if you look closely enough, you'll find a very large proportion of those diesels are Cummins Dependable Diesels.

CUMMINS ENGINE COMPANY, INC., Columbus, Ind.

rather complete electrical and mechanical data were collected. The results of the electrical tests are shown in Table 2.

These data indicate that the electrical and mechanical characteristics of the high slip type motor results in a material reduction in both the peak and average current and power demands. These results are partly due to the fact that the mechanical characteristics of this type motor are ideally suited to the varying pumping load and partly due to the electrical characteristics being well suited to this type load. A typical comparative electrical characteristic curve for high torque normal slip, general purpose, and high slip electric motors are shown in Fig. 1. A critical examination of these curves reveals the fact that the values of motor efficiency and power factor for the high slip are high when the motor is operating on loads below its full load rating. Also, the current consumption of the high slip motor is low in this range. As the torque load of an oil well pumping unit is fluctuating, i.e., it varies from zero to a maximum twice per stroke the prime-mover is called on to deliver power in excess of the average power demand during part of the stroke, and during the remainder of the stroke the power demand is below the average power demand. During the periods when the power demand is less than the full load rating of the motor the high slip motor's advantageous electrical characteristics tend to reduce its power and current consumption.

As the high slip motor tends to shirk the peak loads and permit the rotating masses to help carry these peak loads, the peak power demand placed on the motor is lower when pumping unit is driven with a high slip motor. The kinetic energy given up by these rotating masses during this phase of the pumping cycle are restored during the periods of low power demand. These actions tend to make the power demand placed on the prime-mover more constant. The result of this nearer constant power demand is a reduction in the peak power and current demands when the pumping unit is driven with a high slip motor. This is clearly shown by the two recording wattmeter charts shown in Fig. 2.

As the peak current demand and current fluctuation is lowest with the high slip motor, the normal line disturbance is lowest with this type motor. This characteristic is an advantage when the pumping unit is powered from a small central generating plant. When a number of wells are pumped from a central generating plant, the power peaks from all the wells tend to bunch together and at times will become synchronous. When they become synchronous, a high peak power demand is placed on the generating station. This high peak power demand may cause a voltage drop sufficiently high to trip the under voltage controls on some of the motors. While the high slip motor will not prevent the loads from becoming synchronous, it will decrease the maximum power demand in the event the loads do become synchronous.

It is easier to start the pumping unit when it is powered with a high slip motor due to the fact that the starting characteristics of the high slip motor are better than those of the normal slip motor. As the starting torque of the high slip motor is high, in most instances it is not necessary to rock the well when starting the pumping unit. Also, the starting current demand of the high slip motor is lower than that of the normal slip motor and it places less drastic current demands on the distribution system during the starting period.

The results of an investigation of the loads imposed on the mechanical section of the pumping system are shown in Table 3.

TABLE 3

Motor	Normal slip	High slip
Avg. max. polished rod load..	5,850	5,800
Avg. min. polished rod load..	2,200	2,200
Avg. polished rod hp.....	1.90	2.00
Peak torque, in lb.....	23,000	21,000
Typical dynamometer card..	Fig. 3	Fig. 4

While the results of these tests do not reflect a reduction in the peak polished rod load when the pumping unit is powered with a high slip motor, the results of some tests made by other investigators do show a reduction in the peak load. This variation in results is to be expected because the speed-load characteristics of the high slip motor are such that it will consistently effect only one of the factors entering into the peak polished rod load. This factor is the polished rod acceleration. A recent investigation of the effect of polished rod acceleration on well load has shown that polished rod acceleration is not the predominant factor in determining the maximum polished road load.[1] As the polished rod acceleration is responsible

FIG. 3

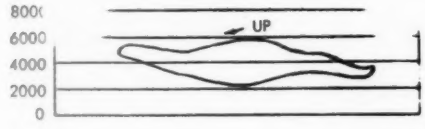


FIG. 4

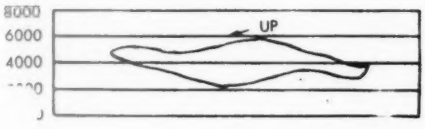


FIG. 5

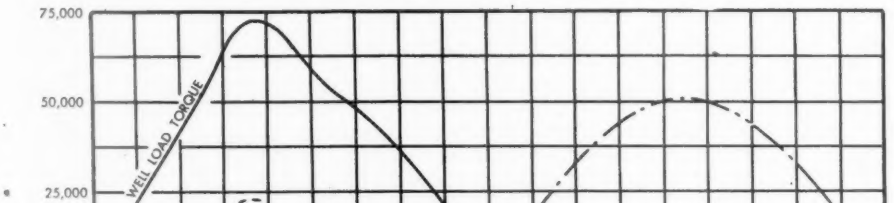
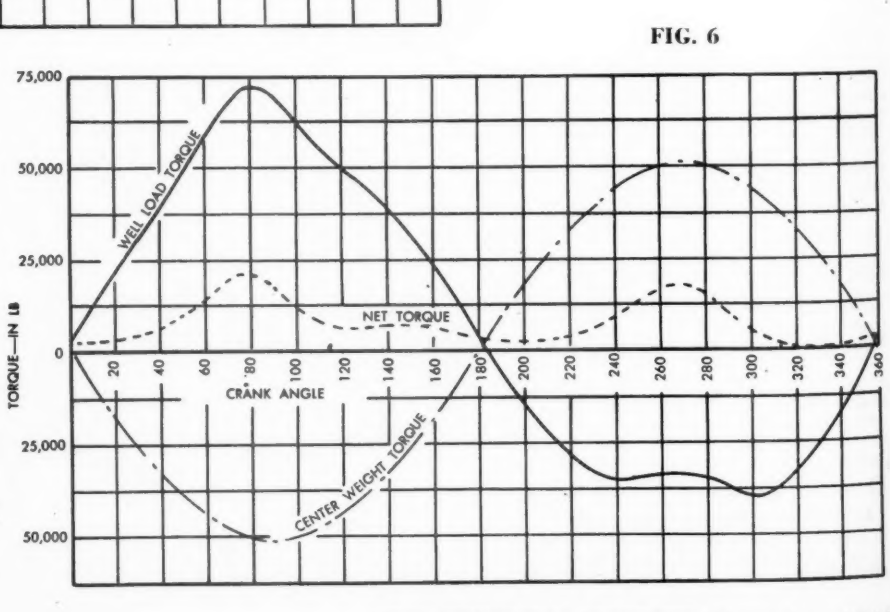


FIG. 6



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for only a small portion of the peak well load, its effect on this factor is so small that the reduction in peak well load resulting from the use of the high slip motor could be dismissed as experimental or instrument errors.

As the instantaneous speed of the pumping system is a function of the speed-load characteristics of the prime-mover, the time intervals elapsing between the opening and closing of the traveling valve will not always be the same when the two types of motors are used on comparative tests. It has been demonstrated that this time interval is one of the predominating factors effecting the peak well load, as this time interval determines how the vibrations in the rod string combined.[2] As this factor is highly variable and is not controllable, it is to be expected that some tests will show material reductions in peak well load when the high slip motor is used as a prime-mover and other tests will not show a reduction and may show an increase.

The peak torque values shown in Table 3 were taken from the torque curves shown in Figs. 5 and 6. Fig. 5 shows the torque when the normal slip motor is used and Fig. 6 shows the torque with the high slip motor. The well load torque values shown on these curves were obtained by determining the well load at intervals corresponding to constant intervals of stroke and substituting these values in the equation:

$$T = \frac{W \times A \times C}{B}$$

where:

T = Torque, in-lb.
W = Instantaneous well load, lb.
A = Normal distance from polished rod to beam saddle bearing, in.
B = Normal distance from beam saddle bearing to center line of pitman, in.
C = Normal distance from center of crankshaft to center line of pitman, in.

The actual torque values of the counterbalance were used to determine the counterweight torque values. While this value is not exactly correct due to the fact that it does not recognize the changes in kinetic energy by this element due to speed changes, the error introduced is one which tends to fail to show the maximum advantage of the high slip motor. In the case of the high slip motor, the effective counterweight torque is increased at the point of peak torque, and thus the net peak torque is reduced to a value lower than these curves indicate. This reduction in peak torque is also shown by the recording wattmeter chart shown in Fig. 2. This phase of the investigation indicates that the peak load imposed on the entire transmission system is lowest when the high slip motor is used as a prime-mover.

1. "Correlation of Polished Rod Acceleration and Well Load" by Kenneth N. Mills, *The Petroleum Engineer*, January, 1944.
2. "Effects of Rod Vibration on Dynamometer Cards" by Kenneth N. Mills and S. E. Corry, *The Oil Weekly*, June 24, 1940.

★ ★ ★

FOR THE DEFENSE OF DEMOCRACY
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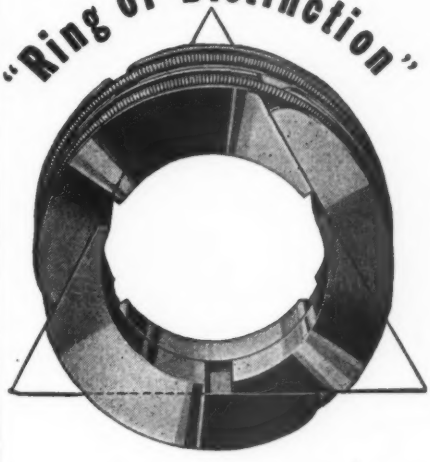


Imitated but never duplicated, the France ring is manufactured in three sections. The contacting faces form the lines of an equilateral triangle. As the ring is expanded or contracted, the sections must move in or out radially equal distances from the center of the rod to which the ring is fitted. This fundamental mechanical principle accounts for the efficiency, trouble-free performance and extra-long life of France Metal Packing.

After years of service, when the rings have become worn to such an extent that the sections nearly butt together, further years of additional service can be obtained by cutting off the narrow points of the three sections where they form a part of the inner circumference of the ring. The spring then requires adjustment so that the sections are held to the rod with a slight tension.

For installation in engines, pumps and compressors—under all conditions of service, France Full-floating Metal Packing means true economy in the long run.
Permit France Engineers to analyze your packing requirements.

ORIGINAL FRANCE METAL PACKING
Sold on approval
Satisfaction Guaranteed

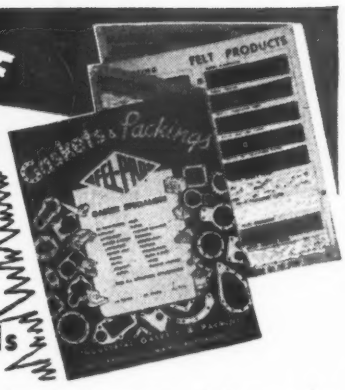
Write for Catalog M-3

☆

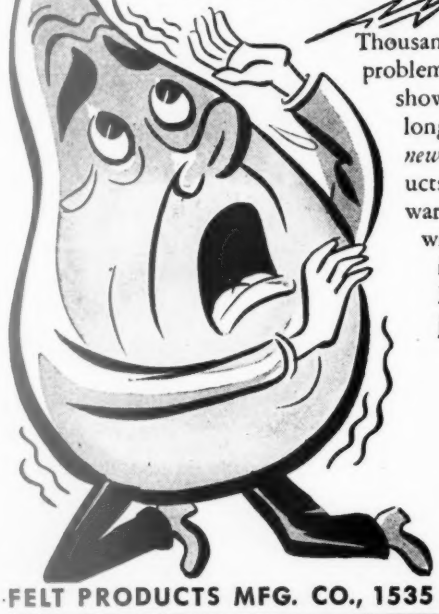
THE FRANCE PACKING COMPANY
Tacony Philadelphia 35 Penna.
Mid-Continent Representative:
MR. J. M. FULLER, 3725 West 7th Street
FORT WORTH, TEXAS

Original FRANCE METAL PACKING

DOOM FOR THE LITTLE DRIP!



When you send for this *FREE FOLIO* of Fel-Pro Sealing Materials



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FULL HP TEST RUN

Double-Checks Power Output of All

WISCONSIN ~~Air-Cooled~~ Engines

Every 4-cylinder V-type Wisconsin Engine, as well as all single cylinder engines from the smallest to the largest, are put on a 4-hour test run (the last hour under full load), working against a specially designed water brake.

This not only serves as an operating check on power output, but also provides a valuable *functional pre-test* of every working part . . . because no engine is any better than its smallest individual part, nor all of the parts working together in perfect mechanical coordination.

All this is important in relation to the work these engines may be called upon to do when *powering your equipment.*

WISCONSIN MOTOR Corporation

MILWAUKEE 14 WISCONSIN U. S. A.

World's Largest Builders of Heavy-Duty Air-Cooled Engines

WRITE TO HARLEY SALES CO.
510 ATLAS BLDG., TULSA, OKLA.
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OIL FIELD DISTRIBUTOR FOR WISCONSIN ENGINES AND ALL TYPES OF UTILITY UNITS

ENGLISH OIL FIELD

The first official indication that oil has been extensively developed in England in war time was given when the veil was slightly lifted and some details made public regarding the output and development. The scene of operations is still a secret. Prospecting and drilling have continued intermittently in Britain since the end of the last war and was encouraged by the Petroleum (Production) Act 1934. The outbreak of war gave a very definite impetus to these surveys. In 1939, the output was given officially as 238 tons a month. Today production is 100,000 tons a year (or 26,000,000 gal.) from more than 230 wells.

The total production in the war period has been 78,000,000 gal. of very excellent quality and capable of utilization as high grade lubricants, even of aviation grades and paraffin waxes.

Coincidental with this vast increase in output there has been a very great increase in efficiency of methods and personnel. Portable drilling equipment is in use and on occasion a complete portable unit has been removed from a site, reassembled, and drilled 960 ft. of hole at a new site all within 24 hours. Producing wells have been completed and put into operation in seven days from the start of drilling and the period of moving heavy machinery from site to site has been reduced to less than 12 hours.

Some 1600 shot holes have been drilled in the main field covering an area of about 1300 square miles pipe lines run to a loading rack nearby and the oil goes by tankcar to refineries. About 1000 workers are employed, operating on a 24-hr. basis. To provide for this continuous effort, canteen and hot meal facilities are in constant use.

The area of the principal field, a single continuous formation, is about two miles long by half a mile wide, the oil bearing strata lying at 2000 to 2500 ft. Tests are continuing at much lower depths, as low as 7000 ft. in one test, but without definite results.

Indications are that the field will continue to give oil in decreasing quantities for from 10 to 15 years at a minimum, and activities are being extended throughout Britain to investigate the further possibilities of oil production.

At the first official visit to the site, Geoffrey Lloyd, secretary for petroleum, said that "This secret oil field came into operation just when we needed every ton of oil to carry this country through the crises of the war. These were supplies which the U-boat could never sink. The annual production (100,000 tons) was equivalent to a fleet of about 12 cross Atlantic tankers."

It has been known for centuries that there was oil in England and survey work by the Anglo-Iranian Oil Company, Ltd., has been continuous over the last inter-war period. The seismic method of survey has been used, and has proved of great value in the work in progress. Their investigations have brought to light a considerable volume of information on geological resources in coal and other minerals. ★ ★ ★

THE *Petroleum* Engineer's CONTINUOUS TABLES

A DAILY REFERENCE FOR OPERATING MEN

INSTALLMENT NO. 89

A VALUABLE and regular feature of *The Petroleum Engineer,* the Continuous Tables, now in their seventh year of publication, were designed to save time and effort for the technician and the practical field or plant worker. The tables have proved one of the most popular and helpful departments of *The Petroleum Engineer.* Data are presented in the simplest form available with many types of information included that are best presented by curves or nomographs when three or more variables must be considered simultaneously.

The Continuous Tables have developed as a result of suggestions for new tables, direct contributions, and improvements to existing tables by members of the petroleum and related industries, including manufacturing concerns, who are continually searching for practical information reduced by computation to tabular form readily applicable to the problems daily confronting them that might otherwise necessitate a more or less tedious calculation. These contributions and suggestions from the industry have resulted in a valuable exchange of information and data contributing to the progress of the industry as a whole.

This index will be revised monthly. The index for installments 1-12, inclusive, will be found in the May, 1938, issue; 13-24, inclusive, in the June, 1939, issue; 25-36, inclusive, in the June, 1940, issue; 37-48, inclusive, in the June, 1941, issue; 48-60, inclusive, in the June, 1942, issue; 61-72, inclusive, in the June, 1943, issue; 73-79, inclusive, in the January, 1944, issue; 80-82, inclusive, in the April, 1944, issue; 83-85, inclusive, in the July, 1944, issue, and 86-88, inclusive, in the October, 1944, issue.

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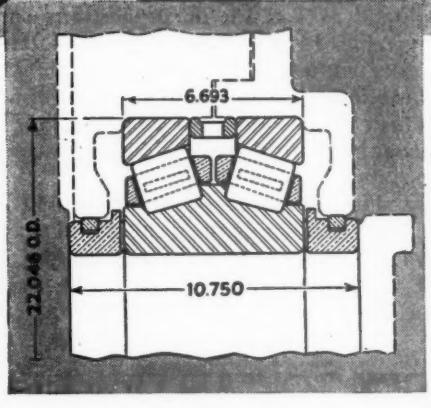
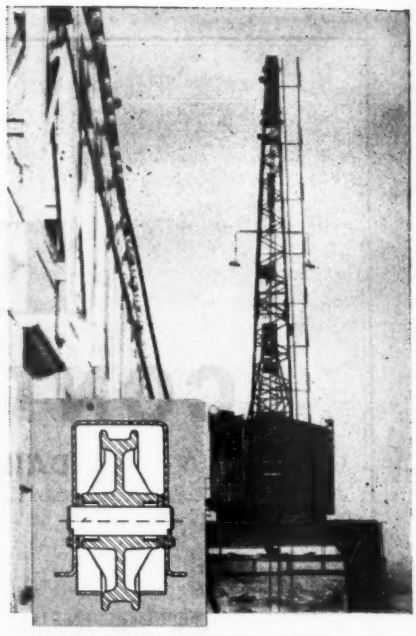
IN THE NEWS
WITH TORRINGTON BEARINGS

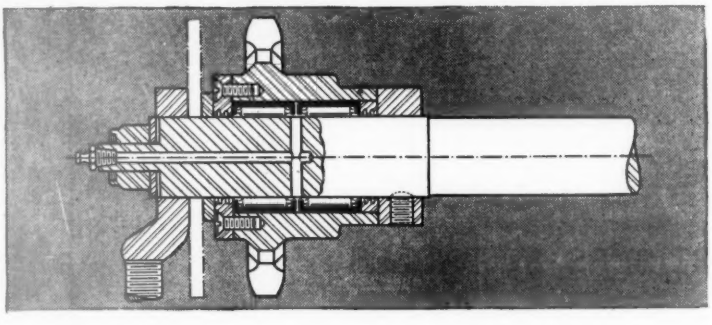
THIS 80" FOUR-HIGH CONTINUOUS HOT STRIP MILL, installed in one of the world's largest steel rolling plants, utilizes Torrington two-row tapered roller bearings (see cross-section) to carry the thrust loads encountered in the operation of the back-up rolls. With each row employing 23 rollers 2¼" long and 2" in diameter, these bearings have a thrust load capacity of 220,900 pounds at 100 R.P.M. Supplying the steel industry with a wide range of anti-friction bearings is an important part of the service of Torrington's Bantam Bearings Division.





THIS MAMMOTH REVOLVING GANTRY CRANE, built by the American Hoist & Derrick Company, entrusts its multi-ton loads to Torrington Needle Roller Bearings, supplied by the Company's Bantam Bearings Division. Combining the advantage of compact design and high load capacity with economy, these anti-friction bearings were specified for installation in the wheels of the crane's equalizing non-swiveling truck, as shown in the accompanying cross-section.

RIGID CONTROL in heat treatment, as in every other phase of manufacture, constitutes a major reason for the successful operation of Torrington Bearings under unusual service conditions. Several methods of heat treatment are employed depending upon the ultimate use of the bearings. Bearing materials are also selected to render the maximum service for the installation conditions. Thus, both heat treatments and materials are carefully engineered to best meet customer requirements.



SHUTTLE CARS, built by the Joy Manufacturing Company, have the distinction of being able both to carry and unload their own cargoes. Designed for the rapid transfer of coal and other materials, these cars discharge their loads within a few seconds by means of a 32" conveyor chain that rides in the center of the chassis. Accompanying cross-section shows the installation of Torrington Type NC Needle Bearings as they are employed in the take-up mechanism of the chain.

ARMY E NAVY

TORRINGTON BEARINGS

STRAIGHT ROLLER • TAPERED ROLLER • NEEDLE • BALL

THE TORRINGTON COMPANY • BANTAM BEARINGS DIVISION

SOUTH BEND 21, INDIANA

HYDROCARBON AZEOTROPES

OLEFINS

ETHYLENE
(—103.9°C.)

Name of entrainer	Boiling point of entrainer, °C.760 mm.	Azeotropic temperature, °C.760 mm.	Azeotropic composition, wt. % H.C.	Reference number
Sulphur dioxide (liq.)	−10.0	No	..	9

PROPYLENE
(—47.0°C.)

Sulphur dioxide (liq.)	−10.0	No	..	9

BUTENE-1
(—6.5°C.)

Anhydrous ammonia (liq.)	−33.4	Min.	..	12
Sulphur dioxide	−10.0	−16.0	..	10
Sulphur dioxide	−10.0	Min.	..	11
Sulphur dioxide	−10.0	−19.0	..	13
Methylamine	−6.5	Min.	..	12
Ethylene oxide	10.7	Min.	..	13
Methyl formate	31.5	Min.	..	13

ISOBUTYLENE
(—6.7°C.)

Sulphur dioxide	−10.0	−14.0	..	10
Sulphur dioxide	−10.0	Min.	..	11
Sulphur dioxide	−10.0	−17.5	..	13
Ethylene oxide	10.7	Min.	..	13
Methyl formate	31.5	Min.	..	13

BUTENE-2-trans.
(1.3°C.)

Sulphur dioxide	−10.0	−14.0	..	10
Sulphur dioxide	−10.0	−16.0	..	13
Ethylene oxide	10.7	Min.	..	13
Methyl formate	31.5	Min.	..	13

BUTENE-2-cis.
(3.7°C.)

Sulphur dioxide	−10.0	−13.0	..	10
Sulphur dioxide	−10.0	−16.0	..	13
Ethylene oxide	10.7	Min.	..	13
Methyl formate	31.5	Min.	..	13

3-METHYL BUTENE-1
(22.5°C.)
(Isopropylethylene)

Sulphur dioxide	−10.0	Min.	..	13
Ethylene oxide	10.7	Min.	..	13
Ethyl nitrite	17.3	<14.0	>30	1
Methyl formate	31.8	14.0	62	1
Methylal	42.3	No	..	1
Methyl alcohol	64.8	19.8	97	2
Ethyl alcohol	78.3	21.9	98	2
Formic acid	100.8	22.2	98	1

PENTENE-1
(30.2°C.)

Sulphur dioxide	−10.0	Min.	..	13
Ethylene oxide	10.7	Min.	..	13
Methyl formate	31.5	Min.	..	13

2-METHYL BUTENE-1
(32.0°C.)
(Methylethylethylene)

Name of entrainer	Boiling point of entrainer, °C.760 mm.	Azeotropic temperature, °C.760 mm.	Azeotropic composition, wt. % H.C.	Reference number
Sulphur dioxide	−10.0	Min.	..	13
Ethylene oxide	10.7	Min.	..	13
Methyl formate	31.5	Min.	..	13

ISOPRENE
(34.3°C.)

Methyl formate	31.9	22.5	50	2
Ethyl ether	34.6	33.2	52	1
Ethyl bromide	38.4	32.0	>65	1
Dimethoxymethane	42.3	33.0	80	1
Methyl alcohol	64.7	29.5	..	2
Ethyl alcohol	78.3	32.7	97	2

PENTENE-2
(35.8°C.)

Sulphur dioxide	−10.0	Min.	..	13
Ethylene oxide	10.7	Min.	..	13
Methyl formate	31.5	Min.	..	13

2-METHYL BUTENE-2
(37.2°C.)
(Trimethylethylene)

Sulphur dioxide	−10.0	Min.	..	13
Ethylene oxide	10.7	Min.	..	13
Methyl formate	31.8	24.3	46	1
Ethyl ether	34.6	34.2	12	1
Ethyl mercaptan	36.2	32.9	40	1
Ethyl bromide	38.4	35.2	40	1
Dichloromethane	41.5	36.9	>88	1
Methylal	42.3	35.3	27	1
Methyl iodide	42.6	No	..	1
Carbon disulphide	46.3	36.5	83	1
n-Propylamine	49.7	32.0	68	2
Ethyl formate	54.2	35.0	70	1
Ethyl formate	54.2	No	..	1
Methyl acetate	57.0	No	..	1
Chloroform	61.2	No	..	1
Methyl alcohol	64.8	31.8	93.3	3
Propyl mercaptan	67.5	No	..	1
Ethyl alcohol	78.3	35.3	96	2
Ethyl alcohol	78.3	No	..	1
Isopropyl alcohol	82.5	No	..	1
Formic acid	100.8	35.0	89.5	1
Isovaleric acid	176.5	No	..	1

3-METHYL-1, 2-BUTADIENE
(40.8°C.)

Methyl formate	31.9	26.5	32	2
Ethyl ether	34.6	No	..	1
Ethyl bromide	38.4	36.0	..	1
Methyl alcohol	64.7	35.0	90	2
Ethyl alcohol	78.3	39.0	..	2

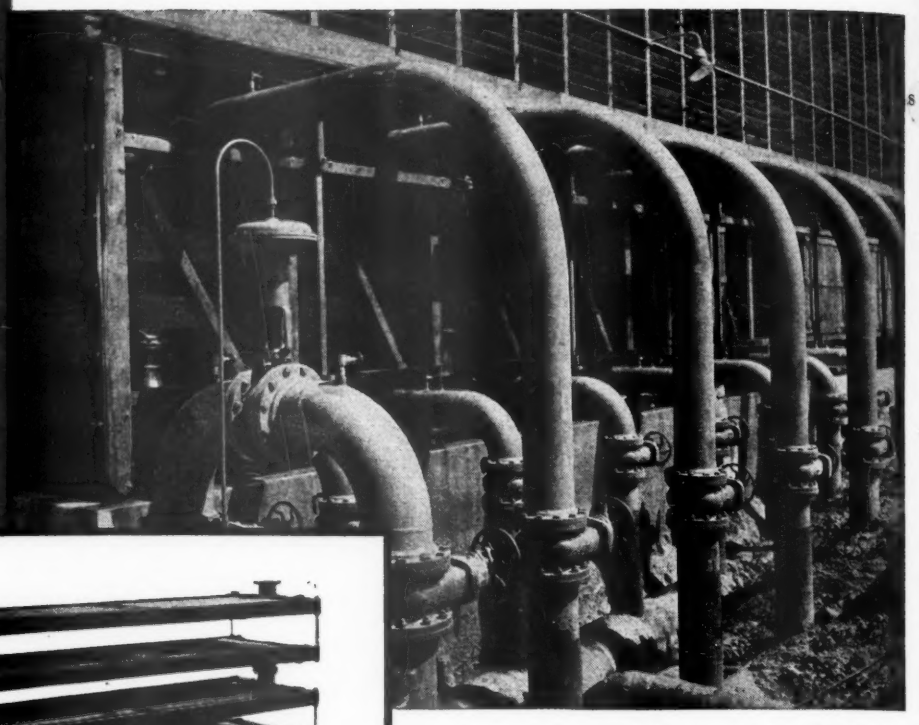
1, 5-HEXADIENE
(60.1°C.)

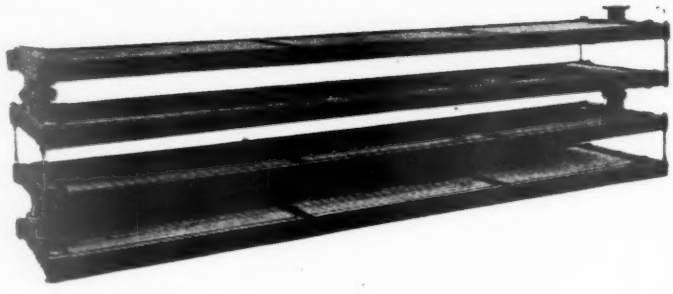
Methyl formate	31.8	No	..	1
Ethyl ether	34.6	No	..	1
Ethyl bromide	38.4	No	..	1
t-Butyl chloride	51.6	No	..	1
Ethyl formate	54.2	45.2	42	2

(Continued)

Literature references and explanation of azeotropic data are on sheet 1—P 721.9.

BENTUBE SECTIONS on Tennessee Gas and Transmission Pipe Line





One of the many G-R Bentube Section installations on the new Tennessee Gas and Transmission Co. pipe line.

NEWS FLASH . . . "All gas coolers and all jacket water coolers on the new Tennessee Gas and Transmission Co. natural gas pipe line are G-R BENTUBE SECTIONS."

Thus, another pipe line joins the long list of BENTUBE SECTION users. These famous scale-shedding units are now being used as coolers by natural gas pipe line companies handling the enormous total capacity of more than 4,500,000,000 cubic feet of natural gas per day.

In addition, BENTUBE SECTIONS are widely used as atmospheric and submerged condensers and coolers in refineries, natural gasoline plants, and chemical process plants all over the country. Bulletin 1601, describing these units in detail, will be sent on request.

THE GRISCOM-RUSSELL CO.
285 MADISON AVE.
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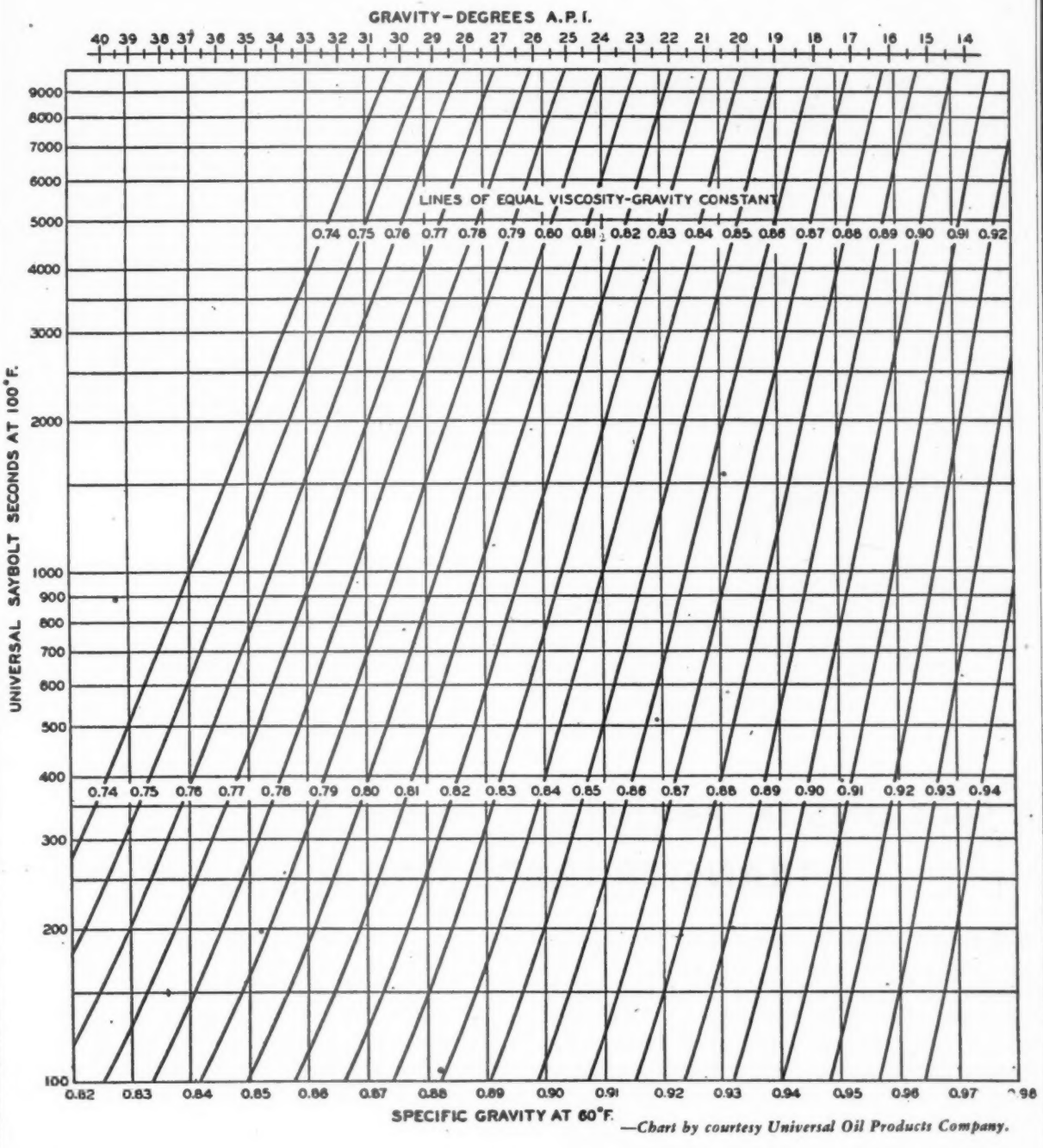
GRISCOM-RUSSELL

Pioneers in Heat Transfer Apparatus

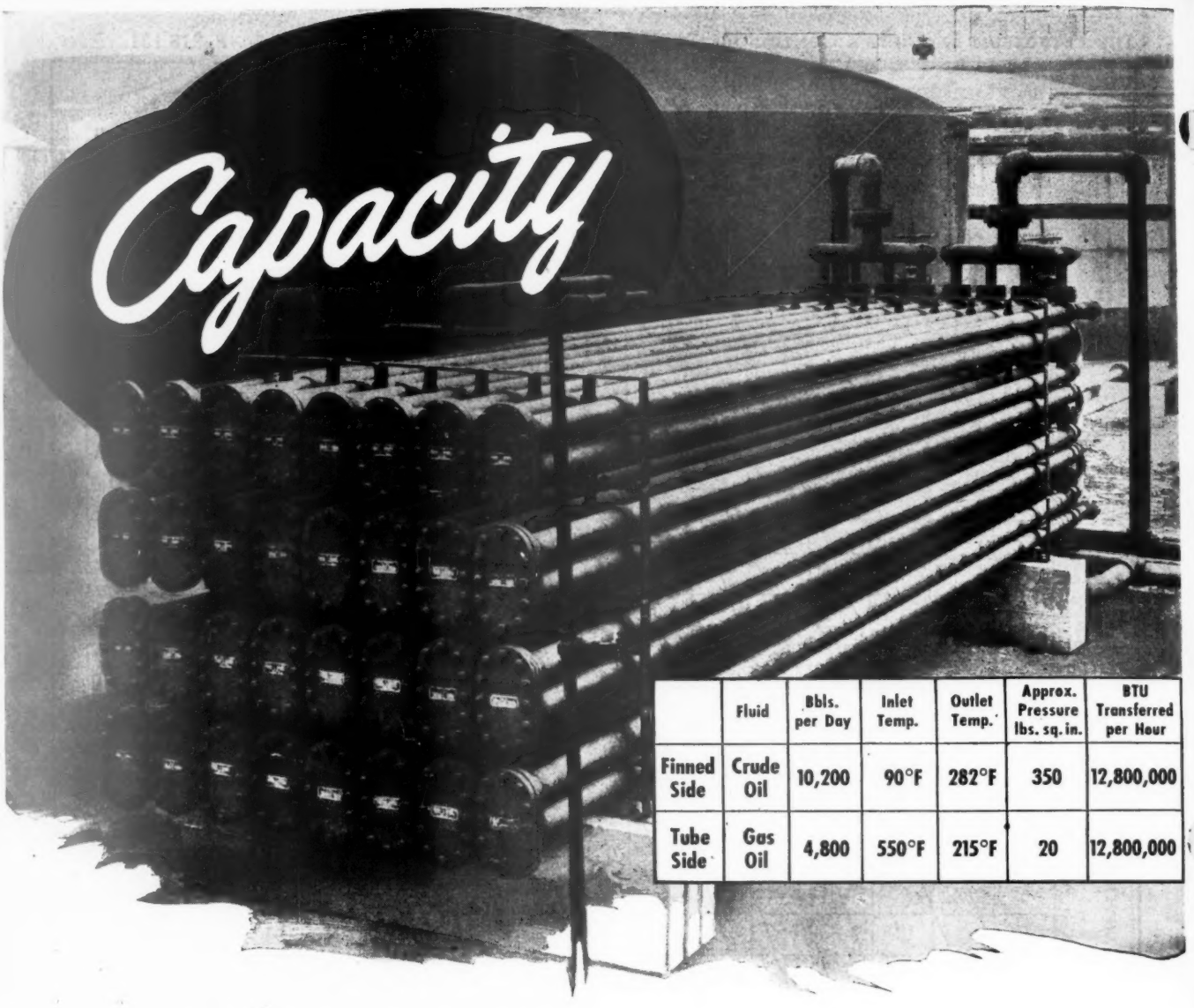
CHART FOR VISCOSITY - GRAVITY CONSTANT



—Chart by courtesy Universal Oil Products Company.

The viscosity-gravity constant is an arbitrary numerical value calculated from the Saybolt viscosity and gravity. It is a classification denoting the paraffinicity or naphthenicity of an oil. The viscosity-gravity constant is "low" for paraffinic oils (0.8) and "high" (0.9) for naphthenic oils.

To obtain the viscosity-gravity constant by the use of the chart, locate the gravity along the bottom of the chart corresponding to the gravity of the sample. Align the viscosity obtained with the one along the left side of the chart. Find the point of intersection of the straight lines from these points. Take the diagonal line closest to this point and read its number. That number plus or minus the interpolated distance from or to the next line gives you the approximate viscosity-gravity constant.



	Fluid	Bbls. per Day	Inlet Temp.	Outlet Temp.	Approx. Pressure lbs. sq. in.	BTU Transferred per Hour
Finned Side	Crude Oil	10,200	90°F	282°F	350	12,800,000
Tube Side	Gas Oil	4,800	550°F	215°F	20	12,800,000

8 SECTIONS IN PARALLEL . . . 4 IN SERIES
TRANSFER 12,800,000 B. T. U. PER HOUR

● Brown Fintube Sectional Heat Exchangers have proved their economy and efficiency under an extremely wide variety of duties. They frequently offer many advantages over bundle type exchangers, even when quite considerable amounts of heat are to be transferred. These advantages include,— great flexibility and high salvage of existing equipment in rearranging to meet changed conditions. Also, with a minimum investment in just a few standby sections, one group after another of the service sections can be taken off line, inspected, cleaned and repaired if necessary while still maintaining full, continuous, uninterrupted operation.

Investigate thoroughly, the advantages of Brown Fintube Sectional Heat Exchangers for every heat transfer service. They will give you, not only all the advantages inherent in the sectional design,— but in addition many exclusive advantages that are available only in Brown Fintube construction. Prices, recommendations, and fully descriptive literature sent promptly. Send for the complete story today.

THE BROWN FINTUBE CO.

125 FILBERT STREET • ELYRIA, OHIO

MANUFACTURERS OF INTEGRALLY BONDED FINTUBES AND FINTUBE HEAT EXCHANGERS

HYDROCARBON AZEOTROPES

OLEFINS—Continued

1, 5-HEXADIENE—Continued (60.1°C.)

Name of entrainer	Boiling point of entrainer, °C.760 mm.	Azeotropic temperature, C.760 mm.	Azeotropic composition, wt. % H.C.	Reference number
Ethyl formate	54.2	47.7	40	1
Acetone	56.2	47.5	53	1
Acetone	56.2	54.5	40	1
Methyl acetate	57.0	51.0	40	2
Ethylidiene chloride	57.5	56.5	33	1
Chloromethyl ether	59.2	55.5	45	1
Chloroform	61.2	55.0	..	2
Ethylpropyl ether	63.6	<60.0	<95	1
Methyl alcohol	64.7	47.1	77.5	2
Ethyl alcohol	78.3	53.5	87	1
Isopropyl alcohol	82.4	55.8	89	2
Formic acid	100.8	54.0	..	1

1, 3-HEXADIENE (80.8°C.)

Name of entrainer	Boiling point of entrainer, °C.760 mm.	Azeotropic temperature, °C.760 mm.	Azeotropic composition, wt. % H.C.	Reference number
Formic acid	100.7	71.0	30	1
Acetic acid	118.5	No	..	1

HEXENE (82.8°C.)

Formic acid	100.7	71.5	31.5	1
Acetic acid	118.5	82.0	2	1

1, 5-HEXADIYNE (85.4°C.)

Methyl alcohol	64.8	47.1	75.9	3
Ethyl alcohol	78.3	53.5	86.4	3

CYCLIC OLEFINS

1, 3-CYCLOHEXADIENE (80.5°C.)

Acetone	56.3	56.1	..	2
Methyl alcohol	64.8	56.4	61.2	3
Methyl borate	68.7	No	..	1
Isobutyl chloride	68.9	No	..	1
Carbon tetrachloride	76.8	No	..	1
Ethyl acetate	77.2	72.8	46	1
Ethyl alcohol	78.3	66.7	65.8	3
Methylethyl ketone	79.6	73	60	1
Isopropyl alcohol	82.4	70.4	64.0	3
t-Butyl alcohol	82.6	73.4	61.3	3
Ethyl nitrate	87.7	76	>60	1
Allyl alcohol	97.0	75.9	79.2	3
n-Propyl alcohol	97.2	76.1	79	3
Formic acid	100.8	71	70	1
Dimethylethyl carbinol	102.0	79.7	85	2
Isobutyl alcohol	107.9	79.4	88.2	3
n-Butyl alcohol	116.9	No	..	1
Acetic acid	118.5	No	..	1

CYCLOHEXENE (83.0°C.)

Methyl acetate	57.0	No	..	1
Methyl alcohol	64.8	55.9	51.4	3
Carbon tetrachloride	76.8	No	..	1
Ethyl acetate	77.2	73.5	>15	1
Ethyl alcohol	78.3	66.7	64.6	3
Methyl propionate	79.9	75.5	..	1
Isopropyl alcohol	82.4	71	63.9	3
t-Butyl alcohol	82.6	73.7	61.9	3
Dichloroethylene	83.7	No	..	1
Thiophene	84.0	<82.5	<85	2
Trichloroethylene	86.9	No	..	1
Dichlorobromomethane	90.2	82.0	..	1
Propyl ether	90.6	No	..	1
Allyl alcohol	97.0	76.3	78.2	3
n-Propyl alcohol	97.2	76.6	77.8	3
Formic acid	100.8	71.5	69	1
Dimethylethyl carbinol	102.0	80.5	..	1
Isobutyl alcohol	107.9	80.5	85.7	3
n-Butyl alcohol	116.9	82.5	..	1
Acetic acid	118.5	81.8	93.5	1

α-PINENE (155.8°C.)

Methanol	64.7	64.5	5	1
Ethanol	78.3	....	..	1
n-Propanol	97.2	97.1	1–2	1
Formic acid	100.7	118.2	1.5	1
Isobutanol	108.0	107.9	5	1
n-Butanol	117.8	117.4	12	2
Acetic acid	118.5	117.2	17	2
Isoamyl alcohol	131.8	130.0	20	1
n-Propyl isobutyrate	134.0	No	..	1
Propionic acid	140.7	136.2	41.5	1
Isoamyl acetate	142.1	No	..	1
Propyl butyrate	143.0	No	..	1
Ethyl chloroacetate	143.5	No	..	1
Methyl lactate	144.8	144.2	10	1
Butyl propionate	146.5	145.8	15	1
Isobutyl isobutyrate	147.3	No	..	1
Bromoform	148.3	146.0	30	1
Amyl acetate	149.0	148.0	25	1
Anisol	153.9	150.5	44	1
Isobutyric acid	154.4	146.7	35	1
Ethyl lactate	155.0	147.0	49	1
n-Propyl isovalerate	155.7	144.0	47	1
Cyclohexanone	155.8	149.8	60	1
Bromobenzene	156.1	153.4	50	1
Chloroacetal	156.8	151.0	45	1
Isobutyl butyrate	156.8	153.0	50	1
Trichlorohydrin	158.0	154.5	50	1
Ethyl bromoacetate	158.2	152.5	54	1
Isoamyl propionate	160.3	154.0	75	1
Cyclohexanol	160.7	149.9	64.5	1
Furfural	161.5	153.0	..	1
Furfural	161.5	143.4	62	2
Pentachloroethane	162.0	162.2(max.)	5	2
Methyl Oxalate	163.3	144.1	61	1
Butyric acid	163.5	152.0	75	1
Ethyl silicate	165.0	149.0	65	1
Butyl butyrate	166.4	No	..	1
Ethyl caproate	167.8	No	..	1
Methyl acetoacetate	169.5	150.5	63	1
Phenetol	170.5	No	..	1
Isobutyl isovalerate	171.4	No	..	1
Methyl n-hexyl ketone	172.9	No	..	1
α-Dichlorohydrin	174.5	152.0	85	1
Isovaleric acid	176.5	154.2	89	1
2-Octanol	178.7	No	..	1
Ethyl acetoacetate	180.7	153.4	78	1
Methyl malonate	181.4	151.5	78	2

(Continued)

Literature references and explanation of azeotropic data are on sheet 1—P 721.9.

LAY·SET PREFORMED is free!

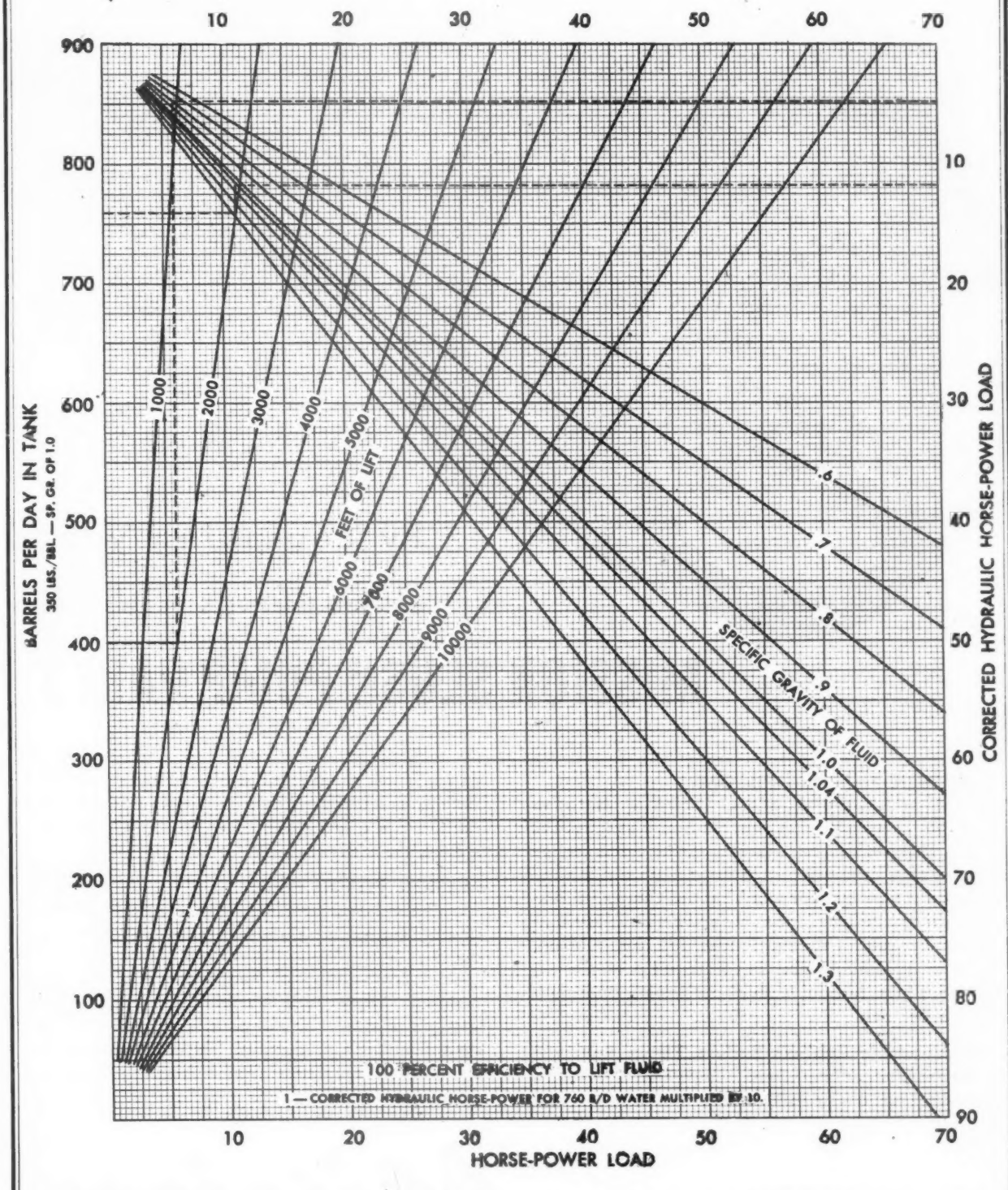
Any aerial acrobat dressed in a strait jacket would probably break his neck. The wires and strands of non-preformed wire rope are virtually in a strait jacket—locked in position and under constant stress—with the result that the rope doesn't perform as well as Hazard LAY-SET which is preformed at the mill and entirely relieved of stresses and strains. LAY-SET Preformed Wire Rope gives you greater dollar value because it requires no seizing when cut; it resists kinking and whipping; it is easier to splice, faster to reeve and safer to handle. Since it has high fatigue resistance, it wears longer.

Hazard LAY-SET Preformed Wire Rope is "in the service" on countless jobs for the Armed Forces where it is proving its many advantages.

HAZARD WIRE ROPE DIVISION • Wilkes-Barre, Pa., Chicago, Pittsburgh, Fort Worth, Houston, Wichita, San Francisco, Denver, Los Angeles • *Distributors in all important oil field centers*
AMERICAN CHAIN & CABLE COMPANY, INC. • BRIDGEPORT, CONNECTICUT

HAZARD LAY·SET ROTARY LINES

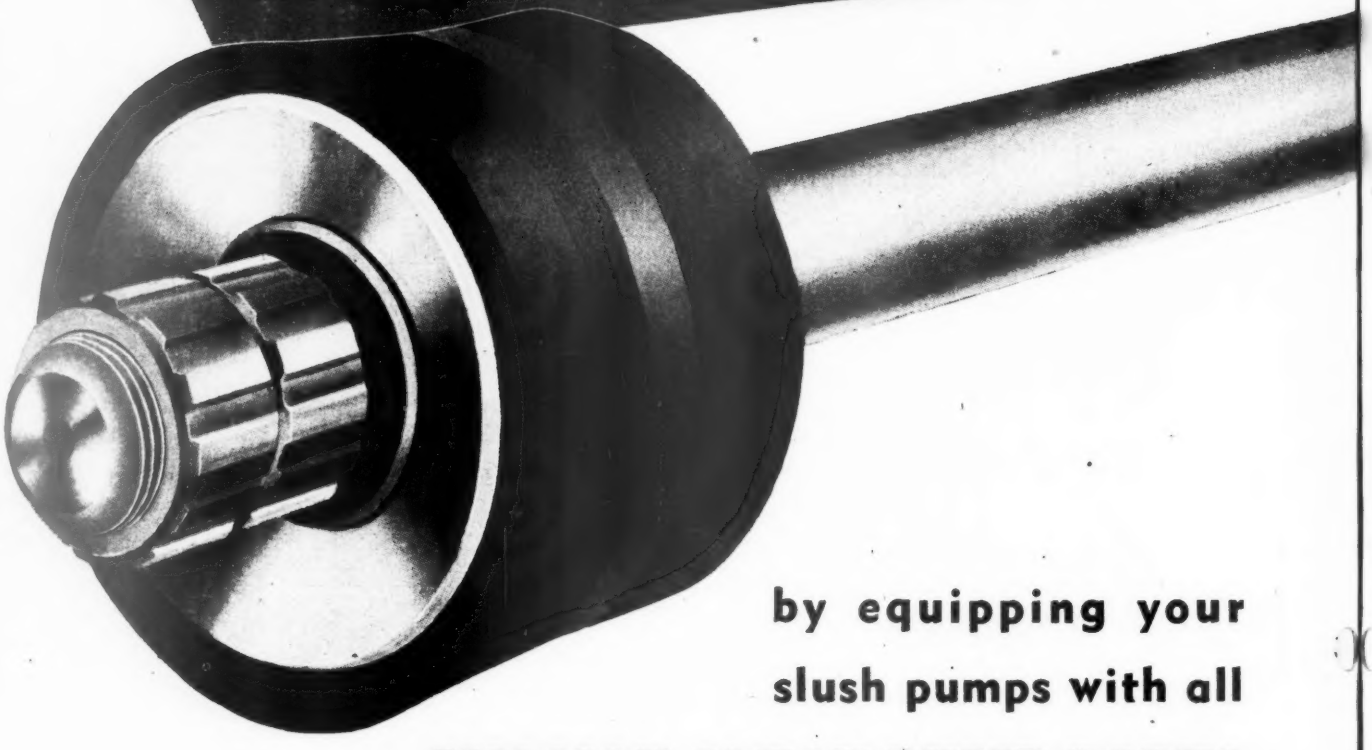
THEORETICAL HYDRAULIC HORSEPOWER TO LIFT FLUID



Example: 400 bbl. per day of oil, sp. gr. 0.832 and 7600 bbl. per day of water, sp. gr. 1.04. Actual lift distance is 2000 ft. Corrected hydraulic horsepower for oil is 4.72 and for water 117.50. Total 122.22.

—Chart by courtesy Kobe, Incorporated.

SPEED UP YOUR DRILLING...



by equipping your slush pumps with all

MISSION SLUSH PUMP PARTS

MISSION *Fluid End* PISTONS
GIVE YOU EXTRA LONG SERVICE **because** of the extremely long, trouble-free piston rubber life. These rubbers are usually giving good service long after ordinary pistons have worn out due to: 1, the combination of tough rubber compound and advanced design; 2, the large wiping surface and positive seal, assuring longer life for rubbers. Other advantages accruing from this principle are longer liner life, more fluid per stroke, and more hole per hour.

Replaceable Rubbers Reduce Piston Renewal Cost—When after a long, uninterrupted run, the rubbers are finally worn out, the piston is renewed at much less than its original cost by simply installing new piston rubbers on the old body. These rubbers are easily replaced at the rig without removing the piston from the rod.

MISSION PISTON RODS
. . . have been the choice of leading operators all over the world for years. The excellent wearing qualities of the file-hard surface is due to Mission's special combination of heat treatment and rod material. These rods combine a core tensile strength of over 120,000 pounds per sq. in. with exceptionally high ductility. This combination of strength and toughness gives maximum protection against rod breakage.

USE ALL MISSION PUMP PARTS
VALVES, PISTONS, RODS AND GLAND PACKINGS

4A-17

Mission MANUFACTURING CO.
HUMBLE ROAD HOUSTON, TEXAS

HYDROCARBON AZEOTROPES

CYCLIC OLEFINS—Continued

∝-PINENE—Continued (155.8°C.)

Name of entrainer	Boiling point of entrainer, °C.760 mm.	Azeotropic temperature, °C.760 mm.	Azeotropic composition, wt. % H.C.	Reference number
Phenol	181.5	152.8	81	1
∝-Dichlorohydrin	183.0	No	..	1
Aniline	184.4	155.3	85	1
Ethyl oxalate	185.6	154.8	80	2
Monochloroacetic acid	189.4	152.0	..	2
Isobutyl carbonate	190.3	No	..	1
o-Cresol	190.8	No	..	1
Methyl succinate	195.5	155.5	90	1
Glycol	197.4	149.5	81.5	2
Ethyl malonate	199.2	No	..	1
Benzyl alcohol	205.5	No	..	1
Propyl oxalate	212.0	No	..	1
Acetamide	221.2	152.5	87	2

CAMPHENE (158°C.)

Formic acid	100.7	No	..	1
Acetic acid	118.5	118.2	3	2
Isobutyl carbinol	131.3	130.4	23	2
Amyl alcohol	131.8	No	..	1
Propionic acid	140.9	137.7	36	1
Isoamyl acetate	142.1	No	..	1
Bromoform	148.3	147.5	..	1
Anisol	153.9	152.7	23	1
Isobutyric acid	154.4	148.1	45	1
Ethyl lactate	155.0	149.0	35	1
n-Propyl isovalerate	155.7	145.0	35	2
Cyclohexanone	155.8	150.6	42	1
Bromobenzene	156.1	155.0	..	1
Isobutyl butyrate	156.8	153.0	37	1
Trichlorohydrin	158.0	156.0	..	1
Ethyl bromoacetate	158.2	154.0	..	1
Isoamyl propionate	160.3	155.5	50	1
Cyclohexanol	160.7	153.0	65	1
Furfural	161.5	146.8	60	2
n-Butyric acid	162.5	152.3	73	1
Methyl oxalate	163.3	145.0	60	1
Ethyl silicate	165.0	150.0	63	1
Ethyl caproate	167.8	159.0	85	1
Methyl n-hexyl ketone	172.9	158.0	90	1
∝-Dichlorohydrin	174.5	154.0	80	1
Isovaleric acid	176.5	156.7	89	1
Butyl isovalerate	177.6	No	..	1
Isoamyl butyrate	178.5	No	..	1
Benzaldehyde	179.2	158.5	85	1
Ethyl acetoacetate	180.4	156.2	70	2
Methyl malonate	181.5	154.6	74	2
Phenol	181.5	155.0	78	1
Dichlorohydrin	183.0	156.0	75	2
Aniline	184.4	157.5	87	2
Ethyl oxalate	185.6	158.5	84	2
Monochloroacetic acid	189.4	154.7	85	2
Isobutyl carbonate	190.3	No	..	1
o-Cresol	191.1	No	..	1
Phenyl acetate	195.7	No	..	1
Methyl succinate	195.5	159.0	90	1
Ethyl malonate	199.2	No	..	1
Acetamide	221.2	156.0	85	2
Propionamide	222.1	156.4	90	2

β-PINENE (164°C.)

Name of entrainer	Boiling point of entrainer, °C.760 mm.	Azeotropic temperature, °C.760 mm.	Azeotropic composition, wt. % H.C.	Reference number
Propionic acid	140.7	139.0	24	1
Chloracetal	157.4	156.2	23	1
p-Chloro toluene	161.3	160.2	..	1
Furfural	161.5	146.3	50	1
Pentachloroethane	162.0	166.0	58	2
Methyl oxalate	163.3	147.1	49	1
n-Butyric acid	163.5	158.0	<62	1
Butyl isovalerate	177.6	No	..	1
Benzaldehyde	179.2	162.0	75	1
Ethyl acetoacetate	180.7	159.5	65	1
Methyl malonate	181.5	158.0	72	1
Phenol	181.5	159.0	75	1
o-Cresol	190.8	No	..	1

METHENE (170.8°C.)

Cyclohexanol	160.7	157.5	38	1
Methyl oxalate	164.2	154.0	30	1
Methyl acetoacetate	169.5	160.0	48	1
Benzyl chloride	179.4	No	..	1
Methyl malonate	181.5	164.0	63	1
Phenol	181.5	164.0	67	1

∝-TERPINENE (p-MENTHADIENE-1, 3) (173.3°C.)

Isobutyl butyrate	156.8	No	..	1
Chloracetal	157.4	No	..	1
Furfural	161.5	154.5	47	1
Methyl oxalate	164.2	155.0	32	1
Isobutyl isovalerate	171.4	170.5	35	1
Propyl lactate	171.7	164.0	50	1
Methyl malonate	181.5	167.0	55	1
Ethyl oxalate	185.7	170.5	70	1

CARVENE (Limonene) (177.9°C.)

Isoamyl alcohol	131.8	No	..	1
Propionic acid	140.9	No	..	1
Isobutyric acid	154.4	151.0	22	1
n-Hexanol	156.8	155.5	21	2
Cyclohexanol	160.7	159.3	26.5	1
Furfural	161.5	156.0	35	2
Methyl oxalate	163.3	156.7	25	1
n-Butyric acid	163.5	160.8	45	1
Butyl butyrate	166.4	No	..	1
Methyl acetoacetate	169.5	162.7	35	1
Phenetol	170.5	No	..	1
Isobutyl isovalerate	171.4	No	..	1
Propyl lactate	171.7	166.4	37	1
Isoamyl ether	172.7	No	..	1
Methyl n-hexyl ketone	172.9	170.5	45	1
∝-Dichlorhydrin	174.5	165.8	57	1
o-Chlorophenol	175.5	175.0	..	1
Eucalyptol	176.3	No	..	1
Isovaleric acid	176.5	168.9	59	1
Butyl isovalerate	177.6	176.0	45	1
Ethyl ∝-bromoiso-butyrate	178.0	174.0	55	1
Isoamyl butyrate	178.6	174.0	53	1
2-Octanol	178.7	174.4	65	1
Benzaldehyde	179.2	171.2	57	1
Benzyl chloride	179.4	174.8	54	1

(Continued)

Literature references and explanation of azeotropic data are on sheet 1—P 721.9.

It's the Nash!

There are no mechanical complications in a Nash Compressor. A single moving element, a round rotor, with shrouded blades, forming a series of buckets, revolves freely in an elliptical casing containing any low viscosity liquid. This liquid, carried with the rotor, follows the elliptical contour of the casing.

The moving liquid therefore recedes from the rotor buckets at the wide part of the ellipse, permitting the buckets to fill with gas from the stationary Inlet Ports. As the casing narrows, the liquid is forced back into the rotor buckets, compressing the gas, and delivering it through the fixed Outlet Ports.

Nash Compressors produce 75 lbs. pressure in a single stage, with capacities to 6 million cu. ft. per day in a single structure. Since compression is secured by an entirely different principle, gas pumping problems difficult with ordinary pumps are often handled easily in a Nash.

Nash simplicity means low maintenance cost, with original pump performance constant over long periods. Data on these pumps sent immediately on request.

No internal wearing parts.

No valves, pistons, or vanes.

No internal lubrication.

Low maintenance cost.

Saves floor space.

Desired delivery temperature automatically maintained.

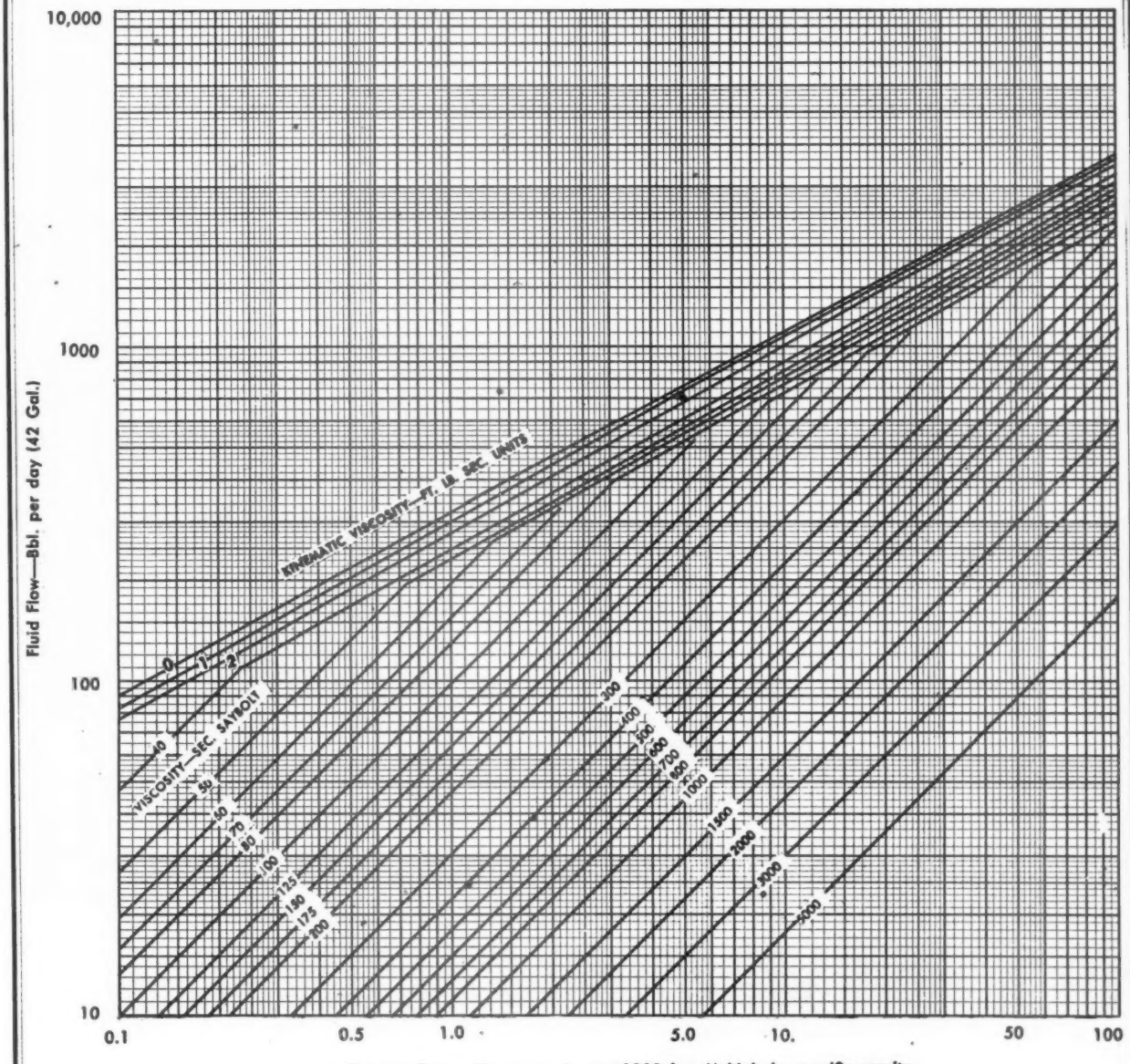
Slugs of liquid entering pump will do no harm.

75 pounds in a single stage.

NASH ENGINEERING COMPANY

323 WILSON, SO. NORWALK, CONN.

PRESSURE DROP IN 2-IN. EXTERNAL UPSET TUBING



—*Chart by courtesy Kobe, Incorporated.*

Tri-Sure News

★ 30 ROCKEFELLER PLAZA, NEW YORK, NEW YORK ★

The Sentinel That Nothing Can Pass

In the four corners of the world,
On guard-duty day and night,
Tri-Sure Closures protect the fuel
In the fight for Freedom's light.

Out there, they guard those drums of oil
For the weapons our boys use,
And safeguard planes and tanks and jeeps
Their cargoes and their crews.

There's no seepage, there's no leakage
When these closures guard the fuel,
For the seal, flange and plug

(A $100.00 War Bond will be given for the best last line)

Verse by Kay Twomey

WIN A $100 WAR BOND — Can you think of a last line for the verse above? A prize of a $100 War Bond will be given for the best line suggested. Try a few now — and send in as many as you wish. Print or type your name and address and mail to Contest Editor, American Flange & Manufacturing Co. Inc., 30 Rockefeller Plaza, New York 20, N. Y., to arrive not later than November 30, 1944. Decision of judges is final. All submissions become the property of American Flange & Manufacturing Co. Inc. No employees of this company or its subsidiaries are eligible to compete.

AMERICAN FLANGE & MANUFACTURING COMPANY INCORPORATED
TRI-SURE PRODUCTS LIMITED, ST. CATHARINES, ONTARIO, CANADA

HYDROCARBON AZEOTROPES

CYCLIC OLEFINS—Continued

CARVENE—Continued (Limonene) (177.9°C.)

Name of entrainer	Boiling point of entrainer, °C.760 mm.	Azeotropic temperature, °C.760 mm.	Azeotropic composition, wt. % H.C.	Reference number
Ethyl acetoacetate	180.7	169.0	57	1
Methyl malonate	181.5	169.0	56	1
Phenol	181.5	169.0	60	1
o-Bromotoluene	181.8	177.3	83	1
Isobutyl lactate	182.2	172.5	60	1
β-Dichlorhydrin	183.0	169.3	60	1
Aniline	184.4	171.4	61.2	1
Ethyl oxalate	185.0	172.2	59	1
Perchloroethane	185.0	No	..	1
p-Bromotoluene	185.0	No	..	1
Chloroacetic acid	186.5	167.8	66	1
Methyl sulfate	188.4	173.0	..	1
Isobutyl carbonate	190.3	No	..	1
o-Cresol	190.8	175.4	75	1
Isoamyl isovalerate	192.7	No	..	1
Dimethyl aniline	194.1	174.0	73	1
Methyl succinate	195.0	No	..	1
Phenyl acetate	195.7	177.5	93	2
Trichloroacetic acid	196.0	171.0	..	1
Methyl aniline	196.1	174.5	87	1
Methyl succinate	196.4	175.5	74	2
Ethylene glycol	197.4	163.0	79	1
Ethyl malonate	198.6	177.5	90	2
Linalool	199.0	No	..	1
Methyl benzoate	199.5	No	..	1
p-Cresol	201.8	177.7	99	1
m-Cresol	202.2	No	..	1
Benzyl formate	202.3	No	..	1
Caproic acid	205.2	177.0	95	2
Benzyl alcohol	205.5	176.3	89	1
Propyl oxalate	212.0	No	..	1
Ethyl succinate	217.3	No	..	1
Acetamide	221.2	169.2	84	2
Glycerol	291.0	177.2	99	2

THYMENE (179.7°C.)

Isobutyric acid	154.4	154.0	..	2
Furfural	161.5	158.5	28	2
n-Butyric acid	162.5	160.5	32	1
Isovaleric acid	176.5	170.5	44	1
Methyl malonate	181.4	169.0	50	2
Phenol	182.2	172.3	60	1
Aniline	184.4	173.5	59	2

THYMENE—Continued (179.7°C.)

Name of entrainer	Boiling point of entrainer, °C.760 mm.	Azeotropic temperature, °C.760 mm.	Azeotropic composition, wt. % H.C.	Reference number
o-Cresol	191.9	178.5	74	1
Phenyl acetate	195.7	179.3	82	2
Methyl succinate	196.4	178.2	68	2
p-Cresol	201.7	No	..	1
m-Cresol	202.2	No	..	1
Benzyl alcohol	205.2	179.0	86	2
n-Caproic acid	205.2	179.0	97	2
Glycerol	291.0	179.6	99	2

√-TERPINENE (p-MENTHADIENE-1, 4) (179.9°C.)

Cyclohexanol	160.7	159.8	..	1
Methyl oxalate	164.2	159.0	22	1
Phenetol	170.5	No	..	1
Methyl n-hexyl ketone	172.9	171.7	35	1
Isoamyl ether	173.4	No	..	1
Isoamyl butyrate	178.5	177.5	43	1
Benzaldehyde	179.2	173.0	52	1
Ethyl acetoacetate	180.7	171.0	49	1
Methyl malonate	181.5	168.0	52	1
Phenol	181.5	171.5	57	1
o-Bromotoluene	181.8	178.5	60	1
Ethyl oxalate	185.7	173.5	55	2
Monochloroacetic acid	189.4	170.0	..	2
o-Cresol	190.8	178.0	73	1
Isoamyl isovalerate	192.7	No	..	1
Methyl succinate	195.4	178.0	68	2
Phenyl acetate	195.7	180.3	85	2
Ethyl malonate	198.6	178.0	78	2
Methyl benzoate	199.5	No	..	1
Benzyl formate	202.3	No	..	1
Benzyl acetate	215.5	No	..	1
Ethyl succinate	217.3	No	..	1

TERPINOLENE (p-MENTHADIENE-1, 4(8)) (185.2°C.)

Furfural	161.5	160.3	20	1
Methyl oxalate	164.2	160.0	10	1
Isobutyl isovalerate	171.4	No	..	1
Isoamyl butyrate	178.5	No	..	1
Methyl malonate	181.5	171.0	38	1
Ethyl oxalate	185.7	175.0	50	1
Methyl succinate	195.5	180.0	64	1

AROMATICS

BENZENE (80.2°C.)

Ethyl ether	34.6	No	..	4
Ethyl bromide	38.4	No	..	4
Carbon disulfide	46.3	No	..	4
Ethyl formate	54.2	No	..	1
Acetone	56.2	No	..	4
Methyl acetate	57.0	No	..	4
Chloroform	61.2	No	..	4
Methyl alcohol	64.8	58.4	39.4	3
Methyl borate	68.7	No	..	1
Isobutyl chloride	68.9	No	..	1
Propyl bromide	71.0	No	..	1
Ethyl iodide	72.3	No	..	4
Butyraldehyde	75.7	No	..	15
Carbon tetrachloride	76.8	....	..	4
Ethyl acetate	77.2	77.0	6	1

BENZENE—Continued (80.2°C.)

Butyl nitrite	77.8	No	..	1
Ethyl alcohol	78.3	68.2	32.4	1
Methylethyl ketone	79.6	78.4	37.5	3
Methyl propionate	79.9	77.5	48	1
n-Propyl formate	80.8	72.0	52.1	3
Isopropyl alcohol	82.4	72.0	66.7	3
t-Butyl alcohol	82.6	74.0	63.6	3
Ethylene chloride	83.7	No	..	4
Diochloroethylene	83.7	No	..	1
Thiophene	84.0	No	..	1
Ethyl nitrate	87.7	80.1	85	1
Isobutyl mercaptan	88.0	No	..	1
Dichlorobromomethane	90.2	No	..	1
Methyl carbonate	90.4	77.5	74	1

(Continued)

Literature references and explanation of azeotropic data are on sheet 1—P 721.9.

• **A NATION'S THANKS** to the men of the petroleum industry for meeting and continuing to beat the wartime task of producing petroleum products in record-shattering volume.

And an orchid or two to the engineers who designed Hyatt Roller Bearings into the equipment whose dependable performance enables the industry to meet the nation's demands.

HYATT *

* *There is a size and type of Hyatt Roller Bearing for every application. Further information on any type for your specific purpose gladly furnished.*

HYATT BEARINGS DIVISION · GENERAL MOTORS CORPORATION

Harrison, New Jersey · Chicago · Detroit · Pittsburgh · Oakland, California

Contest winner

For outstanding excellence and achievement and value to the war effort, the house organ of Lane-Wells Company, *Tomorrow's Tools—Today!* was signally honored recently and selected a winner in the "Leaders of 1944" contest at the convention of the Direct Mail Advertising Association held in New York, it is announced by M. E. Montrose, vice president of services and sales of Lane-Wells Company. This publication was cited as one of the best house organs in the United States or Canada.

Nomads meet

An overflow attendance enjoyed the regular monthly dinner meeting of the Los Angeles Chapter of Nomads held at the Clark Hotel, Los Angeles, October 11. Roland E. Smith, president, introduced Ted Sutter who inducted into honorary membership Charles M. Potter of Richmond Petroleum Company from Venezuela who, because of his sojourn in foreign fields, had not been able to attend a Nomad meeting since his election several years ago.

A short talk on action in the Pacific was given by Lt. L. R. Langey, U. S. Marine Corps.

Hi Cassidy, master of ritual, then inducted C. M. Byron, Baker Oil Tools, Inc., as a regular member, and Stanley Atkinson, MacClatchie Manufacturing Company, as an associate member.

Jim Robinson, chairman of the membership committee, announced that the following men had been elected to membership: Harold S. Armstrong, Lummus Company, regular member; Ward B. Tennis, International Cementers, Inc., regular member; Larry M. Coker, Byron Jackson Company, associate member; H. K. Browning, Kobe, Incorporated, associate member, and T. H. Stancliff, Globe Oil Tool Company, associate member.

After a brief intermission, moving pictures showing the progress and development of television were shown. After their showing Hal Davis of General Electric Company discussed the future of television. Hal Hill of the same company then gave a talk on the application of electrical equipment in military and naval operations. Several reels of action pictures supplied by the U. S. Navy followed. All present got a kick out of some camel pictures provided by Charlie Potter, the pictures being very intimate scenes that he took while in Arabia.

Among those present were Nomad Earl Rees who is now a captain in the Marine Corps and former Nomad H. E. Thompson who is a major in the Quartermaster Corps. Before going into the army, Eddie Thompson was with the N. P. P. M. in Sumatra. With him was Capt. Thomas Eddington who served with him in Australia.

Other foreign guests present at the meeting were: Conway Adney of Mene Grande Oil Company from Venezuela; Gil N. Akin and Howard Keck of Iraq Petroleum Company from Qatar, Arabia; M. H. Bush and F. H. Rhyner of the Kansu Oil Mining Administration from China; A. C. Bush of Drilexo from Brazil; A. T. Bogdonov, F. A. Nisoff, and N. A. Perkov of the U. S. S. R. Commission, Moscow; Mace Freeland, Geo. E. Mackey, and Harry Tyner of the American Arabian Oil Company, Arabia; S. L. Slaughter and L. A. Sweeney of International Petroleum Company from Peru, and Frank R. Wilmer of Caribbean Petroleum from Venezuela.

Trust created

Creation of a trust under which the Guaranty Trust Company of New York is trustee of securities of the Universal Oil Products Company of Chicago for the benefit of the American Chemical Society is announced by Dr. Thomas Midgley, Jr., president of the society.

The trust, known as The Petroleum Research Fund, was set up to administer the gift made by a group of oil companies owning securities in Universal, one of the leading research and development enterprises of the country.

The management and operation of the Universal Oil Products Company will be under the direction of a board of directors to be appointed by the Guaranty Trust Company of New York as trustee.

"The net profit from the Universal Oil Products Company will flow to the American Chemical Society to be used for purposes of research in the petroleum and natural gas field," Dr. Midgley said.

The donors are Shell Oil Company, Inc., Standard Oil Company of California, Standard Oil Company (Indiana), Standard Oil Company (New Jersey), The Texas Company, N. V. de Bataafsche Petroleum Maatschappij.

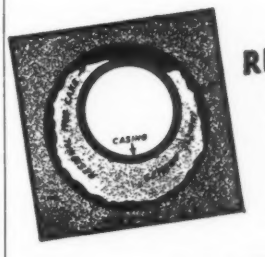
Assistant to president

C. R. Cox, president of National Tube Company, announced at Pittsburgh, Pennsylvania, the appointment of Walter H. Wiewel as assistant to the president of this U. S. Steel subsidiary, to engage in the planning and development of future markets and facilities for the production of tubular products.

Wiewel's previous experience has been largely in the pipe industry, embracing both carbon and alloy steels. Since 1942, he has served as chief of the tubing branch, steel division of the War Production Board, and also as vice chairman of WPB's production directive committee. He will begin his new duties with National Tube Company immediately.

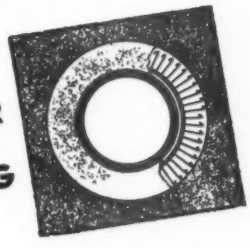
WANTED — By large independent oil operator experienced production superintendent between 30-35 years old, familiar with gas, gas distillate, and oil wells, including dual completions, workovers, squeezing, packer work, etc. Experience with gas, distillate and oil separation problems preferred. Would prefer man with engineering training, but not necessarily a degree. Box 29, care of *The Petroleum Engineer*, P. O. Box 1589, Dallas 1, Texas.

Wall Cleaning Guides Insure a Good Cement Job

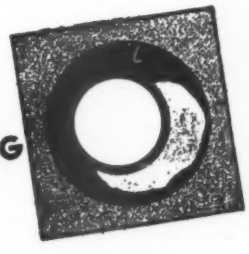


REMOVE MUD CAKE

CENTER THE CASING



PREVENT CHANNELING



REMOVE MUD CAKE. The abrading action of the multiple spring wires removes mud filter cake from wall, and affords good surface for cementing.

CENTER THE CASING. Continuous centering of casing assures uniform thickness of cement — eliminates the dangerous "zone of weakness."

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Named chief engineer

Kieley & Mueller, Inc., North Bergen, New Jersey, announce the appointment of Clifford B. Ives as chief engineer. He has been closely associated with control problems for the last 15 years and will direct the expansion of Kieley & Mueller products in this field.

Promotions made

Announcement of four important organizational appointments in connection with postwar expansion plans, is made by R. E. Ristow, president of Drayer & Hanson, Inc., Los Angeles, manufacturers of heat exchange equipment.

Albert Hanson has been promoted to the position of vice president in charge of engineering. J. C. Lombardi, who has been in special sales capacities for a number of years, has been appointed vice president, director of sales. Scott M. Hauser, vice president, becomes director of sales promotion and advertising. A. H. Witt, who has also been in special sales work for the corporation during the war period, has been promoted to the position of air conditioning and refrigeration sales manager.

Third award

The men and women of Macwhyte Wire Rope Company, Kenosha, Wisconsin, received their third Army-Navy "E" Award on October 7. The first award consisting of an Army-Navy "E" flag and "E" pins was made November 21, 1942. The second award was made August 21, 1943 and consisted of a flag with one star.

This third award is a flag with two stars signifying their ability to merit continually the confidence of the war and navy departments.

Engineering service

R. E. Dansby, for 9 years mud engineer with Stanolind Oil and Gas Company, has established his own mud engineering service in Houston. Offices are in the Sterling Building. During the last 12 years Dansby has been actively engaged in mining and manufacturing mud products, servicing wells, training mud engineers, and doing research work.

In his new undertaking he is offering consultation and complete laboratory services, and is planning drilling mud programs.

Appoints sales managers

Beaumont Iron Works Company, Beaumont, Texas, announces the appointment, effective November 1, of C. J. Harris as domestic sales manager and Neil G. Nuttall as export sales manager.

Harris attended Texas A. and M. College, served in the first World War as a second lieutenant, and then spent 2 years in Tampico, Mexico, with Gulf Oil Corporation. In 1921 he joined the Frick-Reid organization in Mexia, Texas, and in 1926 joined Beaumont Iron Works Company, whom he has since served as sales representative in the Beaumont and Houston districts.

Nuttall attended Vanderbilt and Tulane universities and was employed by the National Shipbuilding Company in Orange, Texas, during World War I. He entered the service of Beaumont Iron Works Company in 1920, and since that time has served in various sales and executive positions with the company.

High test Christmas tree

Oil Center Tool Company, Houston, Texas, whose products are widely used throughout domestic and foreign fields, was host to a large group of oil company and equipment manufacturing officials November 3 to celebrate the successful testing of the world's first 15,000-lb. test Christmas tree manifold.

Heretofore, 10,000-lb. test equipment of this nature has been sufficient to cope with the pressures encountered thus far, but recent deep and extremely high pressure discoveries indicate a definite need for surface control equipment capable of withstanding pressures in the 6,000-7,000-lb. pressure range with a required minimum safety factor of 2 to 1.

A. J. Penick, president of Oil Center Tool Company, points out that the manufacture of 15,000-lb. test equipment is in keeping with a policy of his company to keep ahead of the actual needs of the industry.

THE ADVANCED ENGINEERING AND DESIGN of Honan-Crane "Continuous" Oil Purifiers will give maximum protection for any Diesel engines or compressors under any kind of operating conditions. Honan-Crane "Continuous" Oil Purifiers accomplish thorough purification by removing all types of contamination as fast as they are liberated in the oil. Your engine is lubricated by a constant supply of clean oil.

Send for Bulletin 100D for complete details.

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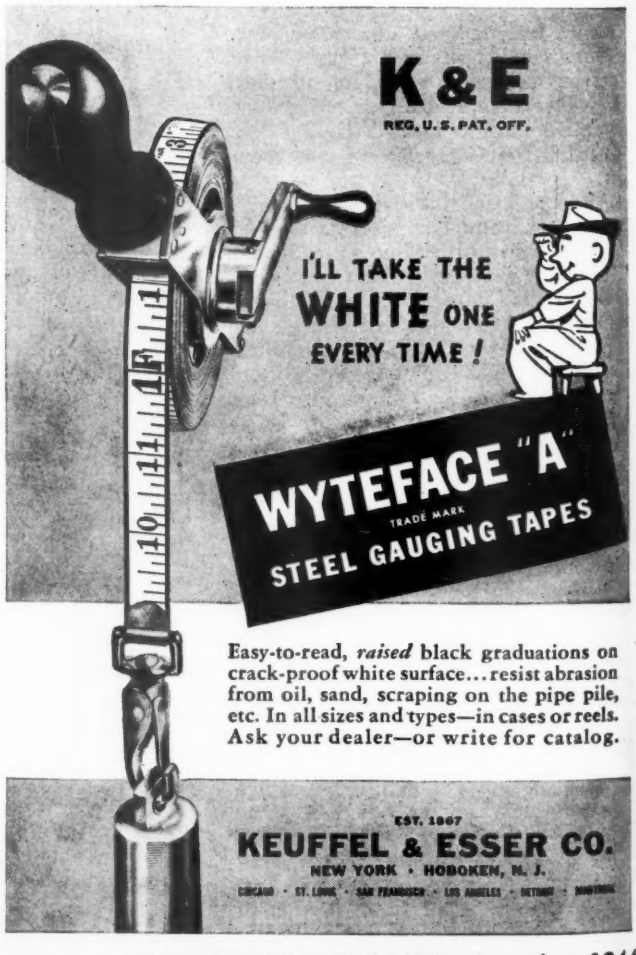

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Running Tour WITH MEN IN THE INDUSTRY

▸ **A. J. Schmitz** has been appointed as Pacific regional manager, Allis-Chalmers Manufacturing Company. He has previously served as manager of the Seattle office. Schmitz joined Allis-Chalmers in 1914, and directed company activities in Cuba for 11 years.

▸ **Norman E. Thompson,** formerly with Republic Steel Corporation, who joined the Rheem Manufacturing Company in January, has been appointed production manager of the nine Rheem plants making up the company's eastern division. These plants are located at Bayonne; New Jersey; Sparrows Point, Maryland; Danville and Williamsport, Pennsylvania; Birmingham, Alabama; New Orleans, Louisiana; Houston, Texas and Chicago, Illinois, two plants.

▸ **R. W. Pennell,** Humble Oil and Refining Company official, died at his home in Houston, Texas, on October 28, after a lengthy illness. Pennell, past president of the Council of Federations, production department, Humble Oil and Refining Company, had been an employee of the company for 16 years.

▸ **Frank Renner** has joined the staff of sales engineers covering the Southern California territory of the Foxboro Company, Foxboro, Massachusetts. His offices are located at 2307 East 8th Street, Los Angeles 21, California. Renner has had 20 years of industrial experience with engineering problems involved in the production of oil and gas.

▸ **Robert Beers** has become a member of the staff of sales engineers, Foxboro, New York office. He has gained considerable experience in industrial fields with Western Electric Company, American Brass Company, and Whitehead Metal Products. For the past two years he has been with WPB.

▸ **F. N. (Frank) Davis,** formerly with Manning-Maxwell and Moore, Inc., has been appointed district manager and factory representative for the Daniel Orifice Fitting Company, Los Angeles, manufacturers of flange orifice fittings, valves and vapor bombs. Davis's offices will be at 310 Thompson Building, Tulsa, Oklahoma.

▸ **Pvt. Claude Ellsworth Howard** of Houston, son of **W. Elray Howard,** vice president of the York Oil Field Service Company of Houston, and Mrs. Howard, was killed in a training flight at Sheppard Field, Wichita Falls, when two training planes crashed at the field.

▸ **Fred A. Henninger,** United States Navy, has been appointed manager of the service department of Anchor Petroleum Company. Henninger will devote his full time to Anchor, producers and marketers of butane and propane. He was formerly in the tank manufacturing business before his assignment in the navy.

▸ **Richard H. Lamberton** has been appointed deputy assistant director, liquid transport division, ODT, to succeed **Porter L. Howard,** who has returned to Sun Oil Company. Lamberton has served as an assistant in the division since March, 1943.

▸ **John W. Sands,** who has been with the conservation division of WPB since January, 1942, has resumed his duties with the development and research division of The International Nickel Company, Inc., at New York.

▸ **Dr. Everett C. Hughes** has been appointed chief of the research division of the manufacturing department, Standard Oil Company of Ohio, succeeding **Dr. R. E. Burk,** who left Standard to accept a position with the E. I. duPont de Nemours Company. Dr. Hughes has been associated with Standard Oil of Ohio since 1930. He was chairman-elect in 1939 and counselor from 1939-42 of the Cleveland Branch of the American Chemical Society. He has been active during the war on a subcommittee of PIWC.

Dr. Everett C. Hughes

▸ **S. H. Rice,** assistant to the general manager of The Texas Company's marine department, died at his home in New York City on October 11. He had been associated with The Texas Company since January, 1914. He served as department agent for Texaco's marine department from 1921 until last May when he was appointed assistant to the general manager.

▸ **Dr. Richard M. Hitchens** has been advanced to the position of associate research director of Monsanto Chemical Company's organic chemicals divisions, it was announced by Osborne Bezanson, divisional general manager of the company. Dr. Hitchens has been with Monsanto since 1931, having started as a research chemist and later becoming a research group leader.

▸ **U. B. Boucke,** vice president and controller of Tide Water Associated Oil Company, has been elected to the board of directors of that company, according to an announcement by President William F. Humphrey. Boucke, connected with Tide Water Associated for more than 23 years, was elected to fill the vacancy created by the resignation of **George J. Hanks.**

▸ **E. Holley Poe,** former executive vice president of Petroleum Reserves Corporation, Washington, D. C., has opened offices at 70 Pine Street, New York City, with branches at 231 South LaSalle Street, Chicago, and 306 National Savings and Trust Building, Washington. **H. C. Orton** is in charge of the Chicago office and **Samuel H. Crosby** heads the office in Washington. Poe, his associates and staff, are engaged in consulting and advisory work concerning all phases of gas utility operation.

▸ **Art Evans** has been appointed sales manager of the Tulsa District, **Empire Oil Field Machinery Company of Odessa, Texas.** His offices are at 706 McBirney Building, Tulsa.

▸ **Lewis Gray,** 84, died at his home on October 9. He was a retired independent oil operator. He entered the oil business with his brother, the late George Gray, early in life and, under the name of Gray Brothers, operated the company for 50 years.

▸ **Myron R. Holmgren,** formerly vice president of the Hughes Oil Company, Chicago, in charge of retail operations, has returned to the company as executive vice president and general manager following a period of several months in which he has been with the OPA. **James C. Scully** will succeed Holmgren.

▸ **Karl Jauman,** after working several years in Punjab, India, on construction work in Trinidad, and on the Canol project in Canada, has completed several months work in the United States, and has gone to Eastern Venezuela for Mene Grande Oil Company. Jauman had experience in Venezuela before going to India.

▸ **Holt McWilliams** has been appointed as West Texas representative for the S. M. Jones Company.

▸ **Ambrose Michael Donoghue,** 64, manager of the crude oil purchases and sales division of The Texas Company, died in Dallas October 16. He was the oldest employee of The Texas Company in point of service, having been with the company for 42 years. Donoghue also was assistant treasurer of The Texas Company and a director of the Texas-New Mexico Pipe Line Company.

▸ **Thomas J. Garin** of Jamestown, New York, has been appointed director of information for the Pennsylvania Grade Crude Oil Association, according to an announcement by W. C. Wenzel, executive manager of the association. He was on the staff of the Bradford District Pennsylvania Oil Producers Association in 1934, and since then has been with various publications in New York, Pennsylvania, and Washington, D. C.

▸ **Kelly R. Johnston,** sales representative for Calumet Refining Company, died in a Chicago hospital October 14. Johnston, 65 years old, had been active in the oil business for many years, including a period in which he was engaged in oil compounding activities in Kansas City. For the last 10 years he has been with Calumet.

▸ **Ernest L. Hughes,** president of Hughes Oil Company, has been appointed special assistant to Harry F. Sinclair, president of Sinclair Oil Corporation. For the past two years Hughes, who has continued as head of his own company, has served as an official of district 2 for PAW.

▸ **Hallam Hans Anderson,** vice president and general manager of Shell Pipe Line Corporation, Houston, Texas, has been appointed national vice chairman of the API's committee on standardization of oil-country tubular goods and a member of its engineer's subcommittee. Anderson returns to API standardization work after an absence of five years.

▸ **Max W. Ball,** noted Denver oil geologist, has been appointed as special assistant to Ralph K. Davies, deputy petroleum administrator.

▸ **H. M. McMillan,** president of the Pilot Royalty Company, Tulsa, Oklahoma, has been promoted to the rank of colonel at Ellington Field, near Houston. McMillan entered the army at the start of the war as a major, later becoming a lieutenant colonel. He began his military career as a private in the Oklahoma National Guard, Bristow, Oklahoma.

▸ **George J. Hanks,** president of South Penn Oil Company; **Earl K. Smith,** Smith Newton Oil Company, Bradford, Pennsylvania, and **Howard J. King,** field superintendent, South Penn Natural Gas Company, Parkersburg, West Virginia, were named to the board of directors of the Pennsylvania Grade Crude Oil Association at a meeting in Bradford recently.

▸ **Howard J. Whitehill,** Tulsa, Oklahoma, was elected president of the National Stripper Well Association at a meeting of the executive committee held recently in Dallas, Texas.

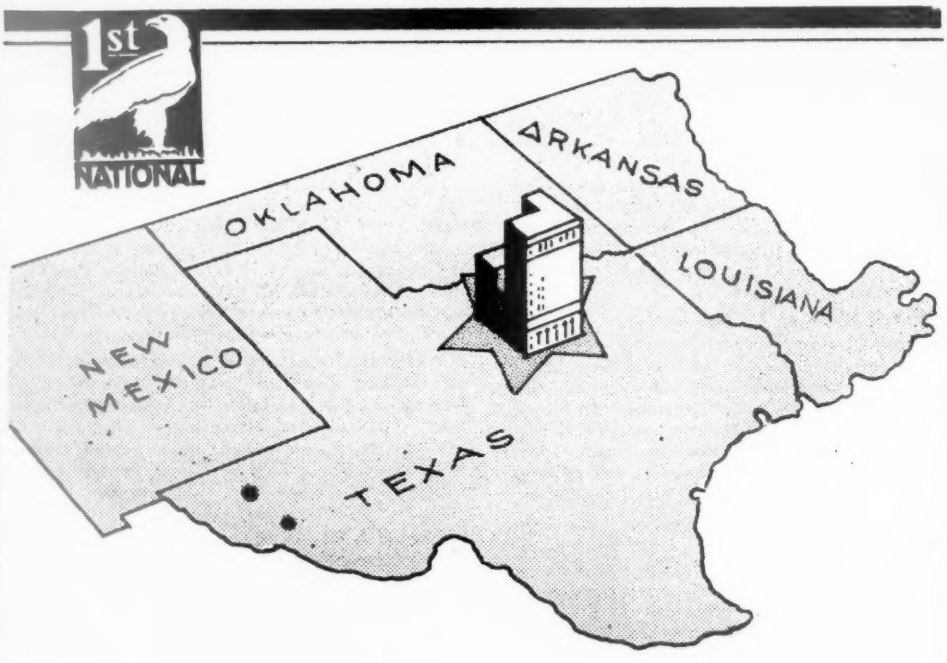
▸ **Carleton J. Everett** has been appointed PAW director of refining in the Atlantic coastal states, and **Edward A. Markey** has been named refining director for the Rocky Mountain states. Everett was formerly with Standard Oil Company of New Jersey and Markey was formerly connected with Continental Oil Company.

▸ **B. C. Voshell** of Socony-Vacuum Oil Company, Inc., New York, has been elected president of the National Lubricating Grease Institute, to succeed **William H. Oldacre** of D. A. Stuart Oil Company, Chicago. Other officers elected are: **Carl Georgi** of Enterprise Oil Company, Buffalo, New York, vice president and **H .A. Mayor,** Southwest Grease and Oil Company, Wichita, Kansas; **L. C. Welch,** Standard Oil Company of Indiana, Chicago; **B. G. Symon,** Shell Oil Company, Inc., New York, and **W. G. Clark,** Pure Oil Company, Chicago, members of the board of directors. All other officers and directors were reelected.

▸ **J. M. Judson,** 67, Evanston, Illinois, died October 25 in an Evanston Hospital. Judson, who retired two years ago from the position of general credit manager and assistant secretary of the Sinclair Refining Company, had been with the company since its organization.

▸ **George P. Dickey,** president of the Dickey Oil Company, has sold all of the common stock of his concern to Stanolind Oil and Gas Company, and has moved to Denver, Colorado, where he will reestablish his oil offices and engage in the development work in the Rocky Mountain region.

▸ **Charles B. Johnson, Jr.,** has resigned as chief petroleum engineer, Seismograph Service Corporation, to take charge of the Agua Dulce plant of The Chicago Corporation, near Corpus Christi, Texas.



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▸ **J. Howard Marshall** has succeeded to the presidency of Ashland Oil and Refining Company replacing **Paul G. Blazer** who resigned the post to become chairman of the board. Marshall has, since 1941, until recently, been chief counsel for PAW and assistant deputy petroleum administrator.

▸ **Joe Gordon** has recently joined the staff of Byrd-Frost, Inc., independent operators of Dallas, Texas, as a petroleum engineer. He has been devoting his time to consulting work.

▸ **John H. Jennings** has recently resigned his position with the Ohio Oil Company, Bakersfield, California, to open consulting engineering offices in the Philtower Building, Tulsa, Oklahoma. Jennings was employed in the Rocky Mountain area with Mountain Fuel Supply Company before going to California with the Ohio Oil Company. Previous to that he was associated with Sunray Oil Corporation, Tulsa.

J. L. Mathieu

▸ **J. L. Mathieu,** vice president of Schlumberger Well Surveying Corporation, has returned to the United States from a six weeks business trip to Venezuela and Trinidad. Mathieu has done extensive traveling for his company. At the outbreak of World War II he was in France where he had gone during the summer of 1939. He returned the last of 1940.

▸ **Dave W. Choate** has been named industrial manager at Atlanta, Georgia, for Minneapolis-Honeywell Regulator Company and its precision industrial instrument division, the Brown Instrument Company. He started with the company in 1936 and has been in charge of the Milwaukee branch of the company's activities. **W. S. Robards** succeeds Choate as industrial sales engineer of the Milwaukee branch. He has been with the company for 8 years.

▸ **F. R. Ficken,** assistant comptroller of Socony-Vacuum Oil Company, Inc., 26 Broadway, will retire on December 1 after 40 years' service with the company. He started with Socony-Vacuum as a clerk in the foreign accounting department and was made chief clerk in 1911. Later he became manager of the department and has been assistant comptroller since 1933.

▸ **L. F. Griffin** has rejoined the staff of the Petroleum Machinery Corporation, New York City, as power engineer in connection with the supply of equipment for power projects in the petroleum industry and other power developments in the foreign field. He recently resigned as deputy chief, Materials Distribution Section, Power Division of Office of War Utilities, WPB, to accept his new duties.

▸ **G. E. Chew** has been appointed assistant superintendent of the Sun Oil Company's Marcus Hook refinery in charge of the personnel division. **H. E. Lawton** was advanced from assistant manager in the personnel division, Marcus Hook refinery, to personnel manager. **C. H. Abbott** and **E. P. King** have been promoted to assistant manager and assistant superintendent in charge of the personnel division, respectively, Toledo, Ohio, refinery, Sun Oil Company. Other promotions by Sun Oil include: **W. E. Zimmerman** to assistant manager, industrial relations department, with headquarters in the general offices in Philadelphia, and **H. W. Munday** to the position of office manager, Toledo refinery.

▸ **C. H. Keplinger** has resigned as division petroleum engineer of the Oklahoma divi-

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Dr. Leo Hendrik Baekeland justly may be called "The Father of Modern Plastics". For, it was this famous research chemist's genius in developing and applying the phenol-formaldehyde resins that gave final impetus for the rise of today's vast field of synthetic plastic materials.

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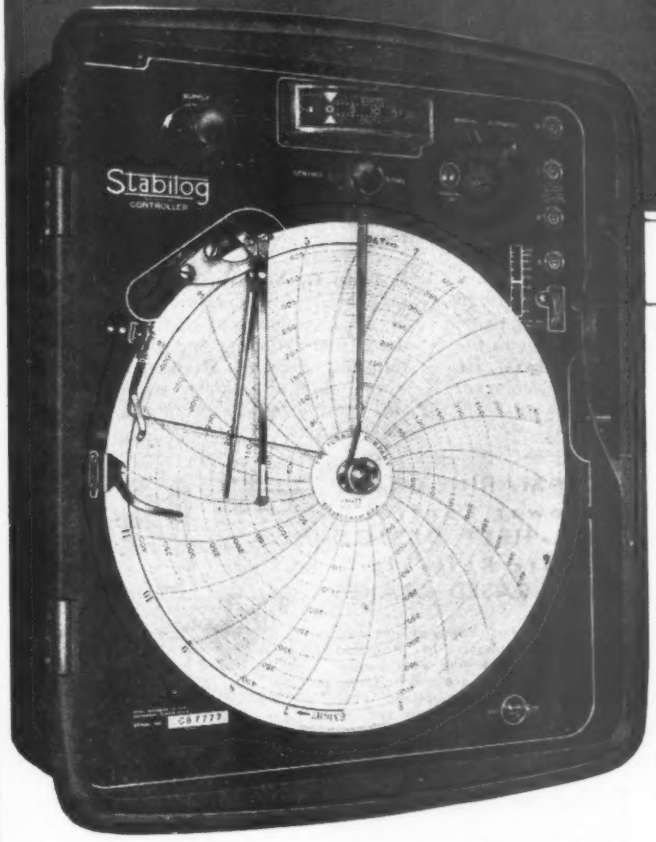

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Only the Model 30 Stabilog Controller supplies full derivative action as automatic function rather than accessory. It gives optimum unit process control with only two adjustments:

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As one of many outstanding examples, Foxboro's Stabilog Controller with Hyper-Reset has introduced unit processing stability never even approached before.

Operating on an exclusive Foxboro rate-sensing principle, this revolutionary instrument provides not only adjustable automatic reset, but selective, measured derivative action. It "feels" the rate of change of disturbance at the very start, and instantly effects corrective action of the proper magnitude. Recovery is often produced in as little as ¼ the usual time – with as much as 50% reduction in amount of upset!

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sion Mid-Continent area, Shell Oil Company, to become an active consulting engineer in Tulsa, Oklahoma. He will specialize in evaluation work, and will aid operators of repressuring outfits.

▸ **Thomas Midgley, Jr.,** 55, inventor of Ethyl gasoline, was found dead in bed at his home in Worthington, Ohio, on November 2. He had been an invalid for 4 years and was confined to a wheel chair at the time of his death. Midgley was a pioneer research worker in synthetic rubber production and did extensive experimentation in the field. He is credited with a number of inventions in the petroleum and allied fields during his lifetime.

▸ **Arthur V. Danner** has been appointed executive vice president of Houdry Process Corporation, Wilmington, Delaware, and **Robert B. Cragin** has been made vice president in charge of sales engineering and a technical adviser of the corporation. Both have been elected members of the board of directors, and Danner has been made a member of the executive committee of the board.

▸ **William Austin Tunstill, Sr.,** 68, a pioneer oil field developer, with holdings in 53 Texas counties, died in Fort Worth, Texas, on October 31 after a 24-hour illness. He had participated in the development of every major field in Texas, except those on the Gulf Coast.

▸ **J. L. Nolan** of Farmers Union Central Exchange, St. Paul, Minnesota, has been elected president of the National Cooperative Refinery Association, a group of cooperative interests operating a 40,000 bbl. a day refinery at McPherson, Kansas. He succeeds **Howard A. Cowden.** Other officers elected are **C. McCarthy,** Omaha, Nebraska, vice president, and **Milo Dahl,** Minneapolis, Minnesota, secretary-treasurer. Directors for the organization are Nolan, Dahl, McCarthy, **Homer Young** and **William Leiman.**

T. W. Cunnea

▸ **Thomas W. Cunnea** has been named branch manager of Westinghouse Electric Supply Company, office in Houston, Texas. He succeeds **C. M. Mackey,** Southwestern district manager of the company. Cunnea joined the company in 1929 as a salesman.

▸ **I. A. O'Shaughnessy,** independent petroleum industry operator, has sold his interest in Wood River Oil and Refining Company, Inc., to his two partners, **O. H. Ingram** and **F. C. Koch.** O'Shaughnessy plans to concentrate his petroleum operations on Globe Oil and Refining Company of Illinois in the refining industry and Lario Oil and Gas Company in oil production.

▸ **Jake L. Hamon** of Dallas, Texas, has been elected to the executive committee of the Independent Petroleum Association of America.

▸ **H. B. Fuqua,** district chief geologist at Fort Worth, Texas, for Gulf Oil Company, has been named recently as assistant to the vice president of Gulf in Houston, Texas. He joined the company in 1922 as a geologist. He is past president of the American Association of Petroleum Geologists.

▸ **Colonel R. B. Harkness,** Ontario natural gas commissioner, has returned from active service overseas, and has resumed his duties in the Ontario Mines Department.

▸ **Technical Sergeant E. B. Roudebush,** former scout for Gulf Refining Company in the Illinois basin area, is reported to be stationed now in Holland with an engineering battalion.

▸ **John E. Galley,** division geologist for Kansas of the Shell Oil Company, has been made assistant to Sherwood **Buckstaff,** exploration manager of Shell for the Mid-Continent area. **John Inkster** has been promoted to division geologist replacing Galley.

▸ **Lieutenant Cecil Hagen,** director of the Independent Petroleum Association of America, has been retired from active service with the United States Naval Air Corps, and has reopened offices in Houston, Texas, as a consulting engineer. Hagen was commander of the training squadron at the air station in Dallas.

▸ **H. J. Wilson,** for a long time active in the West Coast petroleum industry, has been appointed manager of the Marine Department, Associated Division, Tide Water Associated Oil Company. He has been with Tide Water since 1919 and succeeds **George Zeh,** resigned after 42 years with the company.

▸ **John G. Neukom** of Chicago, formerly in charge of fuel rationing for OPA, has been named director of the newly consolidated fuel rationing and automotive supply rationing divisions. **Richard C. Harrison,** former chief of automotive supply rationing, will continue with the division as a consultant on mileage rationing.

WATER from deep wells

ARMY NAVY
PEERLESS PUMPS

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For producing water for refineries and rigs Peerless offers various types of pumps. Choice of oil or water lubricated types. For limited capacities, 50 to 3300 gallons per hour, the Peerless Hi-Lift Pump is ideal. For larger capacities up to 30,000 gallons per minute the Peerless Turbine Pump, as illustrated, is recommended. Electric, belted, gear and steam turbine drives.

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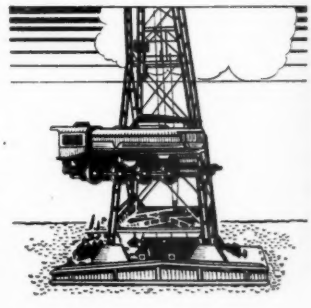

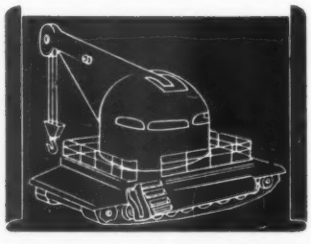

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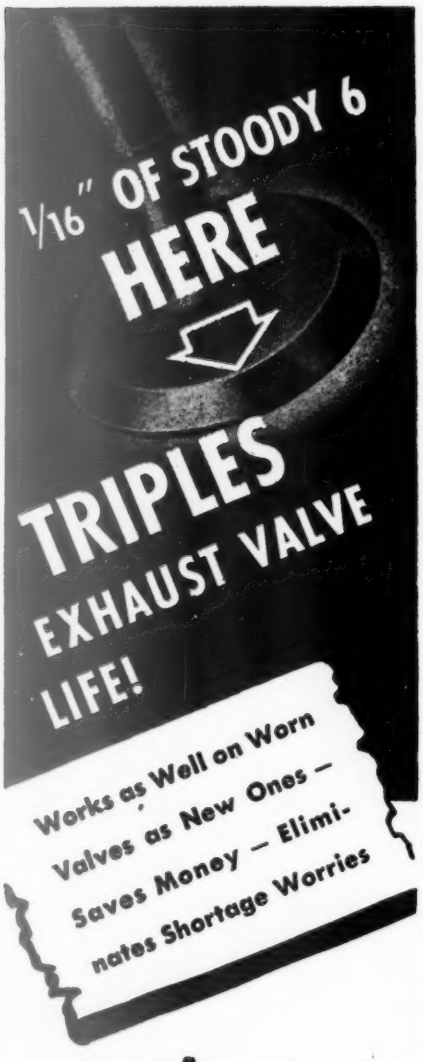
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LAUGH WITH BARNEY

It was the first date.
"Cigarette?"
"No thank you, I don't smoke."
"Let's go down and sip a few."
"I'd rather not. I never touch liquor."
"Well, let's go out on the heights a while."
"No, I'd rather go out and do something new . . . something exciting."
"O. K. Let's go down to the dairy building and milk hell out of a couple of cows."

* * *

Cop: Lady, there's no red light on your car.
Blonde: No, sir. It's not that kind of car.

* * *

Mrs. X, who has two sons in the Marines and a daughter in the WAC, was visiting a farm when she came upon a youth of draft age milking a cow.
"Young man," she asked, sternly, "why aren't you at the front?"
"'Cause there ain't any milk at that end, missus," was the calm reply.

* * *

Show me the woman you say cares nothing for male admiration. Although ordinarily I dread the sight of a corpse.

* * *

A sauntering rookie from Alabama encountered a brisk second lieutenant. "Mawnin'," drawled the rookie pleasantly.
The outraged officer launched a stinging lecture on military courtesy, with emphasis on saluting.
"Lawdamighty," said the rookie, "if I'da knowed you was gonna carry on like that, I wouldn't of spoken to you a-tall."

* * *

Two friends, a Scotchman and an Englishman, were fishing and were "working" the local river. To make things more interesting they agreed that the one who made the first catch would give the other a drink.
Ten minutes later the Scotsman drew the Englishman's attention to the fact that the Englishman had a bite. It was a very poor catch, but the Englishman kept his word and poured out a drink for his pal. "Ah, weel," said the Scotsman, wiping his lips, "I think noo I'll bait my hook."

* * *

Cutie: What did the cannibal say when his men were getting ready to put the shapely looking blonds in the kettle?
Dogface: I'll have my breakfast in bed.

* * *

Along a western highway is a billboard plugging Smith Brothers' Cough Drops with this catch line: "Take One to Bed with You."
Across the bottom of the board some local wag has written: "I wouldn't sleep with either one of 'em!"

* * *

A bishop attended a banquet and a clumsy waiter dropped a plate of hot soup in his lap. The clergyman glanced around with a look of agony and exclaimed:
"Will some layman please say something appropriate."

* * *

"Ah," mused the sergeant, "I well recall that winter. It was bitterly cold."
"I'll say it was cold," said the recruit. "I was brought by a penguin. The stork couldn't make it."

* * *

Girl Friend: Would you like to see where I was operated on for appendicitis?
Boy Friend: No; I hate hospitals.

"We're having a party tonight, and want you come along?"
"Oh, I can't. I'd love to but I haven't a thing to wear."
"That's all right; this is a blind date."

* * *

"How are you this morning?
"All right."
"Well, you ought to notify your face!"

* * *

Mrs. Zilch: (to porter) Have you a ladies' waiting room here?
Porter: "No ma'am, but we have two rooms for ladies who can't wait."

* * *

Not going to do it for a dime anymore
Hurts my back, and makes me sore;
Fifteen cents is now my price,
For twenty-five cents I'll do it twice.
—*Shine Mister?*

* * *

She: Darlin', I'm so discouraged. Everything I do seems to be wrong.
He: M-m-m. What are you doing tonight?

* * *

Jones: How do you spend your income?
Smith: About 30 per cent for shelter, 30 per cent for clothing, 40 per cent for food, and 20 per cent for amusement.
Jones: But that adds up to 120 per cent.
Smith: Don't I know it!

* * *

What kind of a dress did she wear to the party last night?
I don't remember, I think it was checked.
Boy—Must have been a real party.

* * *

Drill Sergeant to the Rookie: Wipe that opinion off your face.

* * *

He: Hello, Beautiful. I understand you are no longer a struggling steno.
Gal: No, when I quit struggling I found I didn't need to be a steno.

* * *

Sweet Young Thing: It's a shameful way that you start making passes at me after half a dozen drinks.
GI: What's so shameful about that?
S. Y. Thing: Wasting five drinks.

* * *

As a colored doorman ran down to open the limousine door, he tripped and rolled down the last four steps.
"For heaven's sake, be careful," cried the club manager. "They'll think you're one of our members."

* * *

Mother: Mary, where have you been until 3 a. m.?
Mary: Walking, Mother.
Mother: For goodness sake!
Mary: Yes, Mother.

* * *

At first it was love. He fascinated me—and I kissed him.
Yeah. I know. Then he began to unfascinate you—and you slapped him.

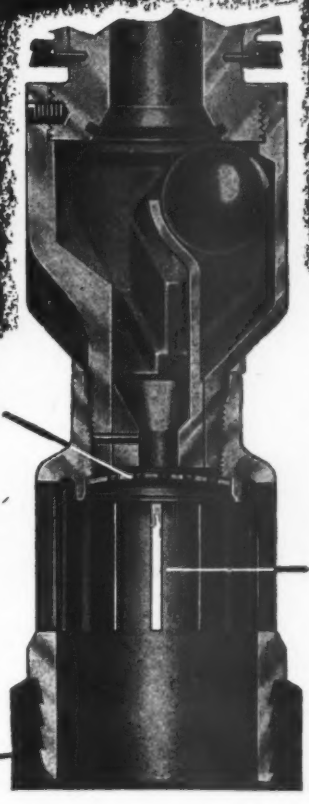
* * *

Prohibitionist Orator: There are some who merely advocate temperance. But what, I ask, is the real drink question?
Voice from back row: What'll you have?

* * *

"Did you get home all right last night, sir?" asked the street car conductor of one of his regular passengers.
"Of course. Why do you ask?"
"Well, when you got up and gave the lady your seat last night, you were the only two people on the car."

This is a BAKER JUNK PUSHER made of drillable material for use with the BAKER CEMENT RETAINER



It is screwed on the threaded tail-pipe connection of the Retainer (right on the rig floor, if desired). It facilitates and safeguards the normal running-in and packing-off of the Retainer.

The rubber sleeve, or scraper, has an O.D. slightly less than the inside diameter of the smallest size casing in which the Retainer is to be run. As the Retainer is lowered, the Junk Pusher scrapes all debris and foreign material toward the center, where it is collected inside the Junk Pusher. This reduces to a minimum the hazard of any material in the well fluid fouling the slips and causing premature setting of the Baker Cement Retainer. The slots permit by-passing of the fluid displaced while the Retainer is being lowered, but no dangerously large fragments can pass through the slots, nor through the screen up inside the body of the Retainer. For its nominal cost, the Junk Pusher is good insurance against premature setting *every* time a Baker Cement Retainer is used, and we suggest that you refer to Page 337 of the Baker (or Composite) Catalog for ordering information; or tell any Baker office or representative that you want one. Order by Product No. 403.

BAKER OIL TOOLS, INC.

Houston—LOS ANGELES—New York

Whitemarsh Research Laboratories dedicated

At a dedication luncheon held recently in the new research laboratories of the Pennsylvania Salt Manufacturing Company at Whitemarsh, Pennsylvania, Leonard T. Beale, president of the company, presented the key to the laboratories to Dr. S. C. Ogburn, Jr., manager of research and development and head of the Whitemarsh Research Laboratories. The guest speaker at the luncheon was C. F. Kettering, general manager, General Motors Corporation, research division. Prominent figures in the world of science, industry, publishing, and education attended.

After the luncheon guests were conducted through the extensive laboratories.

View of speakers' table at dedication luncheon. Left to right: Dr. W. A. LaLande, director of research, Pennsylvania Salt Manufacturing Company; L. A. Smith, vice president and treasurer; Dr. S. C. Ogburn, Jr., manager of research and development and head of Whitemarsh Research Laboratories; Charles F. Kettering of General Motors; Leonard T. Beale, president of Pennsylvania Salt Manufacturing Company; Y. F. Hardcastle, vice president; A. E. Gibbs, advisory technical director of patents; George B. Beitzel, vice president; Walter S. Riggs, development director.

Active head Durametallic

Samuel A. Schaeffer joined the Durametallic Corporation, Kalamazoo, Michigan, as active president on October 30.

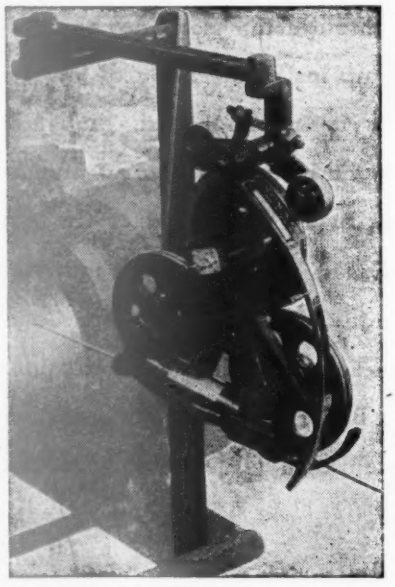
Schaeffer has been identified in the industrial field for many years as vice president and general superintendent of the Clarage Fan Company of Kalamazoo, Michigan. Previously he was foundry superintendent of the Fairbanks-Morse Company of Three Rivers, Mich.

Schaeffer has served as president and chairman of the board of directors of the Durametallic Corporation for many years and his new association with this company in an active capacity is considered an added benefit because of his wide knowledge of machine shop supervision and industrial management.

Goes to Philadelphia

Murray S. Hitchcock, sales engineer of American Meter Company in the Birmingham area, has been transferred to that company's Philadelphia branch, which is under the managership of William G. Hamilton, Jr. Holding the title of production engineer on ordnance work, Hitchcock recently has been appointed assistant chairman of the anti-tank mine container committee, M153, industry integration committee, by the chief of ordnance.

ACCURATE Depth Measurement



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Type B Measure Meter and Weight Indicator, pictured here, gives accurate measurements and eliminates the factor of human error, by indicating on easily read dials, the weight and length of lines in the hole.

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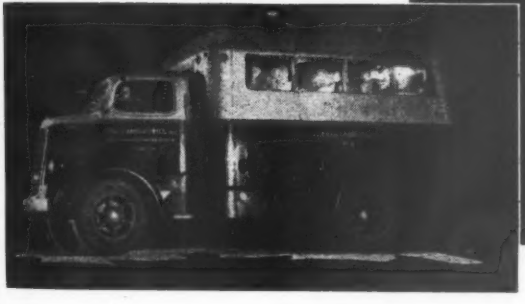

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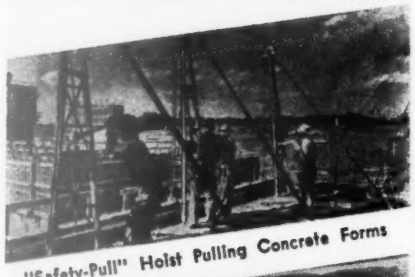

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Schemel with Turco

Appointment of George F. Schemel as petroleum industry representative in Southern California was announced recently by Ray Sanders, general manager, Turco Products, Inc.

G. F. Schemel

Schemel will cover the territory that was handled for many years by Al Dekker. Dekker recently was made procurement manager of Turco, manufacturers of specialized chemical compounds for industry.

New Standard head

Effective January 1, 1945, Robert E. Wilson, president of Pan American Petroleum and Transport Company, will

E. G. Seubert

R. E. Wilson

succeed Edward G. Seubert as chairman and chief executive officer of Standard Oil Company of Indiana. Seubert, who is retiring as active head of Standard of Indiana, has been with the company for 52 years, 15 of which he has served as chief executive officer. He will remain a director and will become chairman of the executive committee of the board of directors. Wilson will become chairman of the board of Pan American Petroleum and Transport Company, a subsidiary of Standard of Indiana, of which he has served as president since 1937.

A. W. Peake, a vice president, will be made president of Standard of Indiana. F. O. Prior, now president of Stanolind Oil and Gas Company, an oil-producing subsidiary, will succeed Peake as vice president of the Indiana company. He will also become a director of the Indiana company and chairman of Stanolind Oil and Gas Company, Stanolind Pipe Line Company, and Stanolind Oil Purchasing Company, of which Peake is now chairman.

Heads Arkansas Natural

D. W. Harris, Shreveport, Louisiana, was elected president of the Arkansas Natural Gas Corporation at the annual meeting of directors in New York. Harris has served as vice president and general manager of the company and its subsidiaries, Arkansas Fuel Oil Company, Arkansas Louisiana Gas Company, and Arkansas Pipeline Company, since 1928.

D. W. Harris

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HOUSTON TEXAS

Pape with W-K-M

W-K-M Company, Inc., manufacturers of the Through-Conduit Lubricated Gate Valve, announce the appointment of Howard Pape as vice president, to be located at the headquarters, Houston, Texas.

Howard Pape has a long history of association with the oil industry, having joined the Tide Water Associated Company in 1915 and a year later becoming associated with Cosden and Company (now Mid-Continent Petroleum Corporation) at Tulsa.

After 10 years of service as chief engineer and mechanical superintendent, he entered the service of Crane Company for the promotion of sales to the oil industry, part of the time being located in New York City and from 1930 to 1935 in the southwestern states. In 1935 he was transferred to the headquarters in Chicago as manager of their valve and fitting department.

Exclusive representative

Sperry-Sun Well Surveying Company announces the appointment of Inland Oilfield Service, Inc., as their exclusive representatives in the Rocky Mountain territory, including the states of North Dakota, South Dakota, Montana, Wyoming, Utah, and Colorado. The main office of the Inland Oilfield Service, Inc. is at 135 North Center Street, Casper, Wyoming.

Glenn N. English is president of this organization and is well known by the oil producers and drilling contractors in the Rocky Mountain area.

John Larkin passes

John J. Larkin, president of the Larkin Packer Company, St. Louis, Missouri, died October 23 at the age of 63. He founded the Larkin Packer Company at Bartlesville, Oklahoma, in 1905, and moved headquarters of the firm to St. Louis in 1920.

Prior to coming to the Mid-Continent he had been associated with his father in the manufacture of oilfield equipment at Butler, Pennsylvania.

Two sons, W. H. Larkin and J. J. Larkin, Jr., both of whom are vice presidents of the firm, are among the survivors. Surviving also are his widow and three brothers, Frank of Tulsa, C. L. of Bartlesville, and W. H., Jr., of Butler.

Statement of Ownership, Management, etc., of THE PETROLEUM ENGINEER September 26, 1944

(This statement is published in compliance with the Act of August 24, 1912.)

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Business Manager: W. T. Bryan.

Stockholders holding 1 per cent or more of total amount of stock: A partnership composed of W. T. Bryan, T. J. Crowley, W. L. Love and K. C. Sclater, all of Dallas, Texas, doing business under the name of The Petroleum Engineer Publishing Company.

Known bondholders, mortgagees and other security holders holding 1 per cent or more of the total amount of bonds, mortgages or other securities: None.

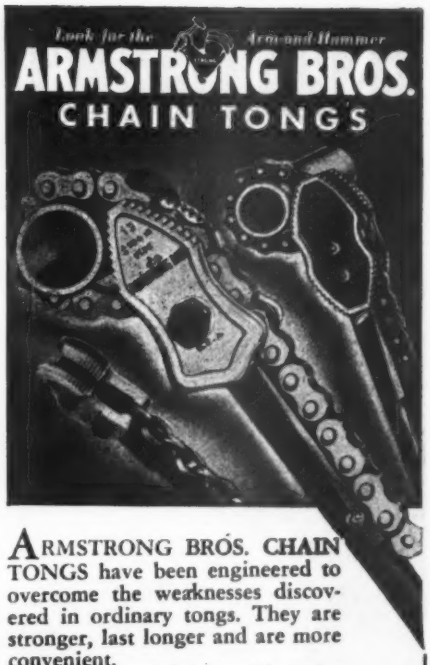
W. T. Bryan, Partner.

Sworn to and subscribed before me this 26th day of September, 1944.

Lillian Haddock Johnston, Notary Public. (My commission expires June, 1945.)

Look for the Arm and Hammer

ARMSTRONG BROS. CHAIN TONGS



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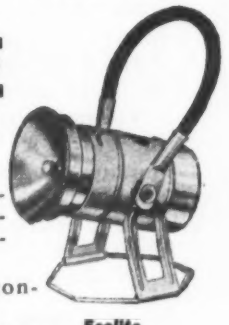

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With Graver Tank

Ben D. Pennington, who has a broad background covering every phase of the oil and gas industry dating from 1918 when he drilled wells in Texas and Oklahoma, and who is also well known around the country and particularly on the west coast as a top-flight construction man, is now associated with Graver Tank and Manufacturing Company, Inc., as manager of its Los Angeles office at 908 South Atlantic Boulevard. His major interests will be directed toward the construction field wherein he has enjoyed notable success.

B. D. Pennington

Recently Pennington completed supervising the construction of a west coast catalytic cracking plant that since has broken all existing records for continuous runs.

Buys Gilmer Company

United States Rubber Company has agreed to purchase the assets and business of the L. H. Gilmer Company of Philadelphia, manufacturers of industrial V-belts, it was announced by Herbert E. Smith, president of the rubber company.

Smith said the purchase was made to round out further the mechanical goods division of the rubber company. He added that no change in the management or operations of the Gilmer company is contemplated. John S. Krauss, president, will continue in the active management of this business.

Study engine developments

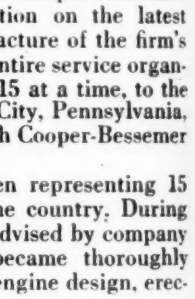
In order to provide field servicemen of The Cooper-Bessemer Corporation with up-to-the-minute information on the latest developments in the engineering and manufacture of the firm's diesel and gas engines and compressors, the entire service organization has been brought, a group of about 15 at a time, to the company's Mount Vernon, Ohio, and Grove City, Pennsylvania, plants. Each group has spent two days at each Cooper-Bessemer plant.

The field service crew consists of 63 men representing 15 branch offices of the concern throughout the country. During their visit, the servicemen were guided and advised by company engineers and technicians so that they became thoroughly familiar with all the latest advancements in engine design, erection, installation, and repairs.

Watson to new job

R. E. Watson has recently become associated with Drilling and Exploration Company, Inc., Dallas, Texas, as assistant to J. E. Brantly, president.

He was graduated from Tulane University in 1927 and entered the oil business with the Southwestern Drilling Company, later going with Humble Oil and Refining Company with which firm he remained for a period of 6 years. He was division engineer at San Antonio when he left to go to Venezuela for the Lago Petroleum Corporation, remaining there until 1941. Followed two years in New York for Standard Oil Company of New Jersey, when he went with Carter Oil Company as division engineer at Shreveport, Louisiana. He left Carter to accept his present position.



R. E. Watson

Joins Kerotest

Kerotest Manufacturing Company, Pittsburgh, Pennsylvania, has announced the appointment of George R. Allen as general sales manager of its brass division, effective November 1.

For the last 8 years, Allen has been associated with Mueller Brass Company, as sales manager of its standard products division.

TRADE LITERATURE

Publications listed are sent free upon request.

▸ A new circular printed in chart form titled *"Guide to Selection of Respiratory Protection"* has just been published by E. D. Bullard Company for general distribution to industry. It stresses the importance of knowing the exact nature of the exposure, gives over ten basic types of hazards and the kinds of respiratory equipment necessary for safety. The circular, No. 944-700, is available on request at E. D. Bullard Company, 275 Eighth Street, San Francisco 3, California.

▸ Tube-Turn, Inc., Louisville 1, Kentucky, has issued a 4-page folder called *"Inside Information About Piping."* It includes helpful engineering data and a complete list of Tube-Turn seamless welding fittings and flanges. It may be had by writing the company and asking for catalog No. 111.

▸ Many practical suggestions for eliminating corrosion and contamination by use of plastic coating are included in a new technical bulletin, *"Amercoat No. 23 Plastic Coating."* The bulletin describes the proved uses of the coating in a wide range of industries. Technical features and product advantages are also covered in detail. Write Amercoat Division, American Pipe and Construction Company, P. O. Box 3528, Terminal Annex, Los Angeles 54, California.

▸ Struthers Wells Corporation has just issued an attractive and informative new bulletin on the company's large line of standard and specially designed *high pressure autoclaves.* The bulletin gives complete information and description on each unit. Also included is a complete list of the equipment designed and manufactured by the company. Write Struthers Wells Corporation, Titusville, Pennsylvania.

▸ A new informative book on *Page-Allegheny Stainless Steel Welding Electrodes* has been issued recently by the Page Steel and Wire Division of the American Chain and Cable Company, Inc. It includes helpful information on welding procedures and recommendations and suggestions on how to select the proper electrode for welding stainless steels. It is divided into two sections, the first devoted to a discussion of the conditions encountered in welding stainless steels and the second giving details on the several types of electrodes. Copies of the book may be obtained by writing to Page Steel and Wire Division of the American Chain and Cable Company, Inc., Monessen, Pennsylvania.

▸ W. C. Norris, manufacturer of oil well pumping supplies, has issued a booklet announcing the inclusion of *Norris Tubing Eliminator* to its line. The new device entirely eliminates the need for tubing, thus saving money, time, and effort in oil production, the company says. Detailed information on the product is available from W. C. Norris Manufacturer, Inc., Tulsa 11, Oklahoma. The bulletin is numbered 34.

Elliott appointments

The election of R. W. Owens as vice president in charge of manufacturing at Elliott Company, Jeannette, Pennsylvania, is announced by Grant B. Shipley, president. Owens joined Elliott Company as assistant to the president in February, 1944, having previously had a wide experience of some 28 years in the design and manufacture of electrical products.

R. W. Owens

The appointment of Frank H. Stohr as assistant to the president is also announced. He has been with Westinghouse Electric and Manufacturing Company as manager of the industry sales department.

Made Young representative

Young Radiator Company, Racine, Wisconsin, announces the appointment of the Rodgers Engineering Company of Dallas as sales and engineering representatives in northeast and north-central Texas.

Rodgers Engineering Company will provide sales and engineering service on the line of Young heating, cooling, and air conditioning products as well as a complete line of complementary accessories.

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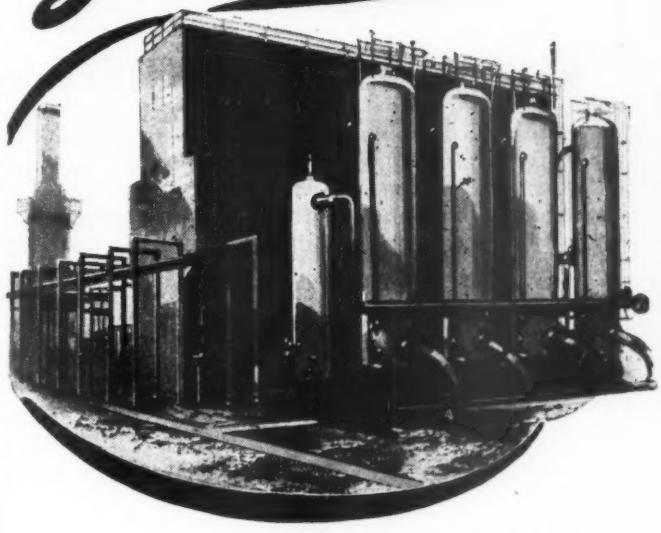

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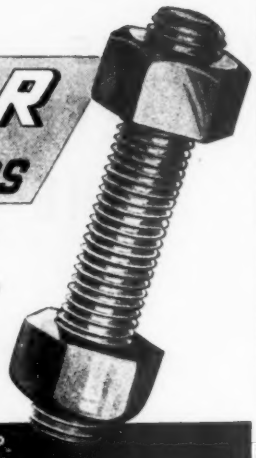

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Book Reviews

▼ **Practical Emulsions,** *by H. Bennett. Chemical Publishing Company, Inc., 234 King Street, Brooklyn, New York. Pages, 460. Price, $5....* This book makes available the latest and most authoritative information in the field of applied emulsions. The writer, a technical director of one of the leading and oldest manufacturers of emulsifying agents and emulsions, has included data and methods from his own broad experience. It is not intended to be a treatise on how to make, use, or evaluate emulsions for industrial use or resale. That feat is yet to be accomplished. But it does correlate much of what has already been found out about emulsions with hitherto unpublished material.

▼ **The Microscope and Its Use,** *by Frank F. Munoz and H. A. Charipper. Chemical Publishing Co., 234 King Street, Brooklyn New York. Pages, 334. Price, $2.50....* A technical book, written in non-technical language, "The Microscope and Its Use" is the first book that covers the field of microscopy from the combined position efforts of two experts. It answers most of the questions that arise in the use and care of simple and specialized microscopes and their attachments, and gives practical instructions and advice in clear simple language.

▼ **Miocene Foraminifera from Sumatra, Java, Netherlands East Indies,** *by L. W. LeRay. Quarterly of the Colorado School of Mines, Golden, Colorado. Pages, 113. Price, $2....* This book is divided into two parts: (1) Miocene Foraminifera of Central Sumatra, Netherlands East Indies; and (2) small Foraminifera from the Miocene of West Java, Netherlands East Indies. It lists and describes the various species of Foraminifera found in places indicated in the title.

▼ **Engine Inspection Practice,** *by A. T. King. Chemical Publishing Co., 26 Court Street, Brooklyn 2, New York. Pages, 236. Price, $3....* Of particular interest to the sub-contractor and small manufacturer is this volume. It is a complete guide to the methods, gauges, and instruments used in engineering production workshops. It is designed, with 246 illustrations, as a text upon which to base a course in inspection practice.

▶ **Review of Petroleum Geology in 1943** *by F. M. Van Tuyl and associates. Quarterly of the Colorado School of Mines, Golden, Colorado. Pages, 127. Price, $1....* Noteworthy events and developments in the fields of petroleum engineering, geology, geophysics, geochemistry, geobiology, aerial photography, fluorescence, and spectroscopy are covered in this volume. It lists some 500 references to publications of the year, compiled through the cooperation of the Research Committee of the American Association of Petroleum Geologists.

▶ **Guide to Weldability of Steels,** *American Welding Society, 33 West 39th Street, New York, N. Y. Pages, 90, Price, $1....* The purpose of this book is to present a practicable method of handling the system of ductility predetermination. Part 1 is an explanation of the system proposed for the predetermination and preservation of desired ductility in the heated zone of higher carbon and low-alloy steels during welding; and part 2 is an instruction manual, with step-by-step examples showing the use of the system to select steels and to predict welding conditions necessary for the preservation of desired ductility in the heated zone.

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